Resource Action: EWG-36	**Task Force Recommendation Category: 2**

Operate the Oroville Facilities to Provide Additional Cold Water in the Low Flow Channel of the Feather River for Benefit of Chinook Salmon and Steelhead

Description of Potential Resource Action Measure:
This measure proposes to change operations of the Oroville Facilities to reduce water temperatures in the low-flow channel of the Feather River (LFC) during certain times of year for the benefit of Chinook salmon and steelhead. The changes in operation would likely include releasing colder water from the reservoir and increasing flow releases to the LFC. As formulated by the EWG, this Resource Action would most likely be implemented from April through October. This period includes the rearing period for spring-run Chinook salmon and steelhead, and the immigration, holding and spawning period for spring-run Chinook salmon.

Date of Field Evaluation: No field evaluation was conducted

Evaluation Team: Phil Unger, review by Brad Cavallo and Mike Manwaring

Related Resource Actions:
Other Resource Actions that are either similar to or otherwise related to this measure include:

- EWG-35A and EWG-35B, which propose to reduce rates of fish predation on juvenile salmonids by reducing water temperatures.
- EWG-37, which proposes to operate the Oroville Facilities in a manner that would provide colder water in Feather River downstream of the Thermalito Afterbay river outlet for benefit of Chinook salmon and steelhead.
- EWG-87, which proposes to modify the Thermalito Complex facilities in a manner to increase water temperatures in the Thermalito Afterbay and reduce temperatures in the Feather River downstream of the Afterbay outlet for beneficial uses.
- EWG-102, which proposes to provide water temperatures in the lower Feather River that mimic historic (pre Oroville Dam) river temperatures to help maintain the genetic integrity of the spring-run Chinook salmon.
- EWG-27, which proposes to fill, modify, or isolate Robinson Riffle Borrow Pit.

Nexus to the Project:
Water temperatures in much of the lower Feather River are strongly affected by operations of the Oroville Facilities. The Oroville Facilities allow project operators to regulate the depth in Oroville Reservoir from which water is released, the amount of water released from the reservoir into the river, the amount of water diverted from the LFC of the river through the Thermalito Complex, and the amount of water pumped

back into the reservoir from the Thermalito Complex. These operational controls give the operators various degrees of control over water temperatures in the LFC.

The 1983 agreement between DWR and DFG, Concerning the Operation of the Oroville Division of the State Water Project for management of Fish & Game, established quantitative water temperature criteria for the lower Feather River. In this agreement, the Oroville Project is required to meet quantitative water temperature criteria at two downstream locations: the Feather River Hatchery (FRH) and the LFC at Robinson's Riffle (River Mile 61.6). Generally speaking, the FRH water temperature criteria serve as the controlling water temperature targets because the Robinson's Riffle criterion is usually satisfied whenever the FRH criteria are met. The FRH criteria vary over the course of a year as shown in the following table:

Period	Temperature (+/- 4°F)
April 1 – May 15	51°
May 16 – May 31	55°
June 1 – June 15	56°
June 16 – August 15	60°
August 16 – August 31	58°
September 1 – September 30	52°
October 1 – November 30	51°
December 1 – March 31	55°

Table 1. Feather River Hatchery Water Temperature Requirements from Oroville Project Operations.

Deviations in FRH water temperature of 4^{o}F above or below the FRH criteria are allowed. The Robinson's Riffle criterion is a daily average water temperature less than or equal to 65^{o}F from June 1 through September 30.

Potential Environmental Benefits:
The EWG fisheries team determined Chinook salmon and steelhead water temperature needs for each life stage by synthesizing information obtained from the fisheries literature. Both fall-run and spring-run Chinook salmon spawn in the LFC beginning in early September (Table 2). The EWG team determined that spawning and egg incubation water temperature requirements for Chinook salmon are no more than 56^{o}F or 58^{o}F (the two values reflect minor differences in the set of literature sources used for deriving the critical temperature estimates). Steelhead begin spawning about December, but continue spawning until approximately April, and egg incubation can continue through May. The EWG team determined that spawning and egg incubation temperature requirements for steelhead are 52^{o}F and 54^{o}F (again, the two values reflect differences in the set of literature sources used for estimates). Spring run adults hold in pools in the LFC from late spring through summer and fall run migrate upstream in late summer and hold more briefly. The EWG team determined that upstream migration and holding temperature requirements for adult spring-run and fall-run Chinook salmon are

60°F and 64°F (as before, the two values reflect differences in the set of literature sources used for estimates).

Life stage Activity/ Species or Run	Period	Upper Water Temperature Limit*
Spawning and Egg Incubation		
Spring-run Chinook	September – mid February	56°F & 58°F
Fall-run Chinook	September – mid February	56°F & 58°F
Steelhead	December - May	52°F & 54°F
Immigration and Holding		
Spring-run Chinook	March - October	60°F & 64°F
Fall-run Chinook	mid July - December	60°F & 64°F
Steelhead	September – mid April	52°F & 56°F

* Two values reflect minor differences in literature sources used to derive temperature limits.

Table 2. Months and Temperature Limits of Chinook Salmon and Steelhead Lifestages.

The suitability of water temperature conditions in the LFC for salmon and steelhead was evaluated by comparing the water temperature limits in Table 2 to results of benchmark study water temperature modeling runs of existing (2001) conditions. The benchmark study simulates water temperatures at different locations based on current level-of-development hydrology and the current regulatory framework. The study estimates natural variability by using the 1922 through 1994 water year hydrology and meteorology for the water temperature simulations. Figures 1 through 4 present results of the study for three locations in the LFC: the Fish Barrier Dam, Robinson's Riffle and a site 0.4 miles upstream of the Thermalito Afterbay river outlet. The Fish Barrier Dam marks the upstream limit of the LFC, Robinson's Riffle is 5.55 river miles downstream of the Fish Barrier Dam, and the site upstream of the Thermalito Afterbay outlet is 7.85 river miles downstream of the dam. Figure 1 shows typical and extreme water temperatures for each location and month, as represented by the median of the daily average water temperatures, the 95th percentile of the daily maximum water temperatures and the 5th percentile of the daily minimum water temperatures. The figure also shows the most critical upper water temperature limits for each month, as described below. The results show that in all seven months, the median water temperature increases downstream from the Fish Barrier Dam to Robinson's Riffle and the site upstream of the Thermalito Afterbay outlet. Also, the median water temperatures at all three locations increase from April through August, and then decline. Figures 2 through 4 provide exceedance plots for daily average water temperatures in April through November at the three LFC locations.

Table 3 gives the frequencies, as percentages, that the salmon and steelhead water temperature limits are exceeded for each month from April through November at each of the three locations. These results are based on the temperature limits in Table 2 and the exceedance data in Figures 2 through 4. For each month from April through November, Table 3 gives the species/life history stage activity with the most restrictive (coldest) water temperature limits, the two water temperature estimates of those limits from Table 2, and the percentage of days during each month that the daily average water temperature exceeds each limit. These percentages are provided for the three locations in the LFC; the Fish Barrier Dam, Robinson's Riffle and upstream of the Thermalito Afterbay river outlet. For September, October and November, the temperature limits and exceedance frequencies are provided for two species/life stage activities, spring-run and fall-run salmon spawning and egg incubation and steelhead immigration and holding. Although steelhead immigration and holding has colder water temperature requirements than salmon spawning and egg incubation, the latter are considered to be more critical because of the greater sensitivity of spawning and egg incubation to unsuitable water temperature conditions.

Month	Limiting Species/Life Stage*	Upper Temperature Limits (^{o}F)**	Frequency of Exceeding Limits (%)		
			Fish Barrier Dam	Robinson's Riffle	Above TAO
April	SH S&E	52 and 54	7 and 2	50 and 20	73 and 38
May	SH S&E	52 and 54	35 and 8	89 and 64	96 and 82
June	SR I&H	60 and 64	0 and 0	25 and 2	49 and 11
July	SR & FR I&H	60 and 64	4 and 0	56 and 6	81 and 29
August	SR & FR I&H	60 and 64	15 and 0	82 and 15	97 and 42
September	SR & FR S&E; SH I&H	56 and 58; 52 and 56	40 and 13; 84 and 40	84 and 63; 100 and 84	95 and 79; 100 and 95
October	SR & FR S&E; SH I&H	56 and 58; 52 and 56	9 and 2; 74 and 9	45 and 19; 95 and 45	59 and 32; 97 and 59
November	SR & FR S&E; SH I&H	56 and 58; 52 and 56	9 and 0; 66 and 9	21 and 6; 79 and 21	29 and 12; 82 and 29

* SH=steelhead, SR=spring-run chinook, FR=fall-run chinook, S&E=spawning and egg incubation, I&H=immigration and holding
** Two values reflect minor differences in literature sources used to derive temperature limits.

Table 3. Frequencies of Exceeding Temperature Limits of Limiting Species/Life Stage during each Month based on Benchmark Study Simulation Results

The results in Table 3 show that the temperature limits are sometimes exceeded in almost every month and location in the LFC. However, there are large differences in the exceedance frequencies among the locations. Other than the steelhead immigration and holding temperature limits, the limits are satisfied at the Fish Barrier Dam more than 50% of the time in every month, and in most months they are satisfied at least 90% of the time. At Robinson's Riffle, which typically is substantially warmer than the Fish Barrier Dam location during the late spring through early fall period (Figure 1), the frequencies of exceeding the temperature limits are consistently higher. They are especially high in May, August and September. At the site upstream of the Thermalito Afterbay outlet, the temperature limits are exceeded more than half of the time in most months. More specifically, April and May water temperature conditions are generally unsuitable for steelhead spawning and egg incubation at the two downstream locations in the LFC, and the same is true of September and October water temperature conditions for salmon spawning and egg incubation. Summer water temperatures are generally suitable for salmon immigration and holding only at the upstream location.

This finding is consistent with results of the relicensing study, SP F10, Task 1E, which concluded that summer water temperatures in the upstream portion of the LFC near the Fish Barrier Dam are suitable for spring run holding, but water temperatures in the downstream portion of the LFC are generally not consistently suitable for spring run holding.

It should be noted that the frequencies of occurrence should not be equated to probabilities because water temperatures on a given day are not independent events, but rather tend to be related to temperatures on neighboring dates. As a result, water temperatures of a month within a year tend to be more similar than those of the same month in other years. This is significant because it means that the probability of exceeding a temperature limit every year is actually somewhat lower than suggested by the frequencies in Table 3. Nevertheless, the results clearly indicate that reducing water temperatures in the LFC, particularly in the more downstream portions of the LFC, would benefit salmon and steelhead.

Although the salmon and steelhead water temperature limits are frequently exceeded at the two downstream locations in the LFC, the level of exceedance is usually relatively small. As shown in Figure 1, the median water temperatures at Robinson's Riffle and the above-Thermalito site are generally within a degree or two of the temperature limits. Although water temperatures occasionally exceed the limits substantially, as indicated by the 95^{th} percentiles of the maximum water temperatures, such extreme water temperature conditions are by definition rare. These results suggest that much of the time only minor changes in project operations would be required to satisfy the water temperature requirements of salmon and steelhead.

Potential Constraints:
As previously noted, this Resource Action would likely include releasing colder water from Oroville Reservoir and/or increasing flow releases to the LFC. However, several important potential constraints could limit these changes in operations. The most immediate potential constraint is the requirement to meet the FRH water temperature criteria. Releasing colder water from the reservoir could cause water temperatures to drop below the criteria. However, because the reductions in water temperature required for this measure would often not be large, this potential constraint would probably only occasionally affect the implementation of the Resource Action.

A major potential constraint on this measure is the need to maintain current Oroville Project contributions to the statewide water supply. The Oroville Project is one of many water projects coordinated to meet California's water supply needs. Releases from the different storage reservoirs of the State Water Project and Central Valley Project are carefully managed in a coordinated fashion to satisfy irrigation, municipal and environmental demands without unduly risking future supplies. The amount of water released from Oroville Reservoir cannot be substantially altered without disrupting this system. Increasing Oroville Project deliveries at one time would generally require reductions in deliveries at other times, and such reductions could be mitigated only by requiring other water projects to increase their deliveries or by reducing demand. The Oroville Project cannot reduce demand or alter the delivery schedules of other water projects. If the total releases from the Oroville Facilities cannot be changed, the amount of flow released into the LFC can be increased only by reducing diversions to the Thermalito Complex.

The amount by which diversions to the Thermalito Complex can be reduced is limited because of the water rights of farmers that divert from the Complex. At times, the irrigation demands of these farmers consume all but about 800 cfs of the flow released from Oroville Reservoir, so no more than 800 cfs is available for release to the LFC (Olson 2004). More flow could be released to the LFC when the reservoir releases exceed the irrigation demands by more than 800 cfs, but such increases would result in fluctuations in LFC flow, which could adversely affect habitat in the LFC. This and other factors discussed below constrain increases in LFC flow in many years, except for flood control purposes.

In addition to being constrained by water supply considerations, substantial increases in LFC flows are constrained by habitat considerations. Instream flow studies of fish habitat (PHABSIM) indicate that the availability of spawning habitat for Chinook salmon and steelhead in the LFC are maximized at a flow of about 800 cfs. Therefore, water temperature benefits potentially gained by increasing LFC flow above 800 cfs could be offset by habitat reductions.

Another major constraint on this Resource Action is the limited volume of Oroville Reservoir's cold-water pool. The limited volume of cold water in the reservoir restricts how much and for how long water temperatures in the LFC could be reduced. This constraint would be particularly significant in dry and critically dry water type years.

The loss of generation that would likely accompany implementation of the measure is another important potential constraint on this measure. Operations that can be used to reduce water temperatures in some or all of the LFC include increasing flow releases to the LFC (as previously discussed), reducing pump-back and peaking operations, and opening the Oroville Dam river valve. These actions would typically result in losses in hydroelectric power generation.

This measure could also be constrained by regulatory requirements. A narrative objective for water temperatures in the Feather River below the Thermalito Afterbay river outlet requires water temperatures that are suitable for shad, striped bass and other warmwater species from May through August. Reducing spring and summer water temperatures in the LFC could make it difficult to meet this objective. Measures to reduce water temperatures in the LFC are also potentially constrained by the goal to supply rice farmers with warm water during spring and summer and by the goal to provide suitable warm water for recreation activities.

Existing Conditions in the Proposed Resource Action Implementation Area:
The LFC is situated downstream of the Oroville Dam, extending about eight miles from the Fish Barrier Dam to the Thermalito Afterbay outlet. The average monthly water temperatures in the LFC near the Fish Barrier Dam typically range from about 46°F in winter to about 58°F in summer. Water temperatures typically drop sharply from August to September (Figure 1), largely because the FRH water temperature criterion for September is much lower than that for late August (52°F vs. 58°F).

Water temperatures in the upstream end of the LFC are generally determined by the FRH temperature requirements, while water temperatures at downstream locations are determined by whatever warming or cooling occurs in the LFC as the water flows downstream from the Fish Barrier Dam. Results of the benchmark study water temperature modeling runs were used to assess rates of warming in two reaches of the LFC during April through October. The upper reach, from the Fish Barrier Dam to Robinson's Riffle, is 5.55 miles long and the lower reach, from Robinson's Riffle to the site upstream of the Thermalito Afterbay Outlet, is 2.3 miles long. Rates of warming are generally similar between the two LFC reaches, with increases in median average daily water temperatures ranging from about 0.5°F per river mile during April and October to about 0.8°F per river mile during June and July (Figure 5). Because of the difference in the length of the two reaches, total warming in the upper reach is considerably greater than that in the lower reach (see Figure 1).

During extreme years, water temperature increases in the LFC are substantially greater than those described above. The 95th percentile increase was about 1.25°F per river mile in the lower reach during July and in both reaches during June (Figure 5). The June increases result in a total increase for the LCF of about 10°F (7.06°F in the upper reach and 2.98°F in the lower reach).

Because of the influence of warm water inflow from the Thermalito Afterbay outlet, water temperatures in the Feather River just downstream of the outlet are often several degrees warmer than temperatures in the lower part of the LFC. At times, back flow from the Thermalito Afterbay outlet and warm water released from Robinson Pond may contribute to temperature increases in the final mile of the LFC. The sudden increase in water temperature at the Thermalito Afterbay outlet may be stressful for migrating fishes, and also elevates predation risk because of the increased abundance of piscivorous bass and Sacramento pikeminnow, which are less tolerant than the salmonids of the cold water temperatures in the LFC.

Design Considerations and Evaluation:
Engineering and Operations water temperature modelers are currently evaluating effects of different project operations on water temperatures in the LFC. Results of the modeling simulations will be used to develop specifics of how project operations could be modified to implement this Resource Action.

The effectiveness of this measure would be evaluated by comparing water temperatures measured at several locations in the LFC before and after implementing the measure. The comparisons would use water temperature modeling to adjust for differences in atmospheric conditions and other potentially confounding variables in making the comparisons. Water temperature data currently being collected in the LFC will provide the information on water temperatures before implementing any changes in project operations.

Synergisms and Conflicts:
This Resource Action is compatible with Resource Actions EWG-37 and EWG-102, which share with EWG-36 the resource goal of providing desirable water temperatures for coldwater fish. By benefiting coldwater fishes, the Resource Action would likely enhance recreation in the LFC, providing increased summer angling opportunities for trout and Chinook salmon. This Resource Action would enhance improve habitat conditions for anadromous salmonids and potentially improve upstream passage through the fairly steep thermal gradient at the end of the LFC, which are resource goals of many of the proposed resource actions. The colder water that would result from this resource action might also help reduce predation on juvenile salmonids in the Thermalito Pool, upstream of the Afterbay outlet, because colder water in the Pool would reduce metabolic rates of the fish predators in the Pool, and thereby potentially reduce their feeding rates. Reduced predation on juvenile salmonids is the basis for Resource Actions EWG-35A, EWG-35B and EWG- 27.

This Resource Action would potentially conflict with a number of resource goals. These include providing warmer water to Thermalito Afterbay for agriculture (e.g., EWG-87), increasing production of coldwater fishes in the reservoir, and enhancing water contact recreational opportunities in the lower Feather River. Depending on the methods used to reach desired temperatures, this resource could also have considerable costs in terms of lost power generation. However, to the extent that more water is diverted through the LFC rather than through the Thermalito Complex, this resource action also has the potential to allow warmer waters for agricultural diversion from the Thermalito Afterbay (EWG-87).

Uncertainties:
Important uncertainties related to this measure include:

- Whether the amount of water in Oroville Reservoir’s cold-water pool during dry and/or critically dry years would be sufficient to effect the proposed reductions in water temperatures, particularly during late summer and fall, and how a reduction in the volume of the cold-water pool would affect the cold-water fisheries of the reservoir.
- Whether the Resource Action could be implemented without conflicting with DWR agreements or goals, including the FRH water temperature criteria, the goal to provide suitable water for the needs of rice farmers, and the agreement to provide water temperatures downstream of the Thermalito Afterbay outlet from

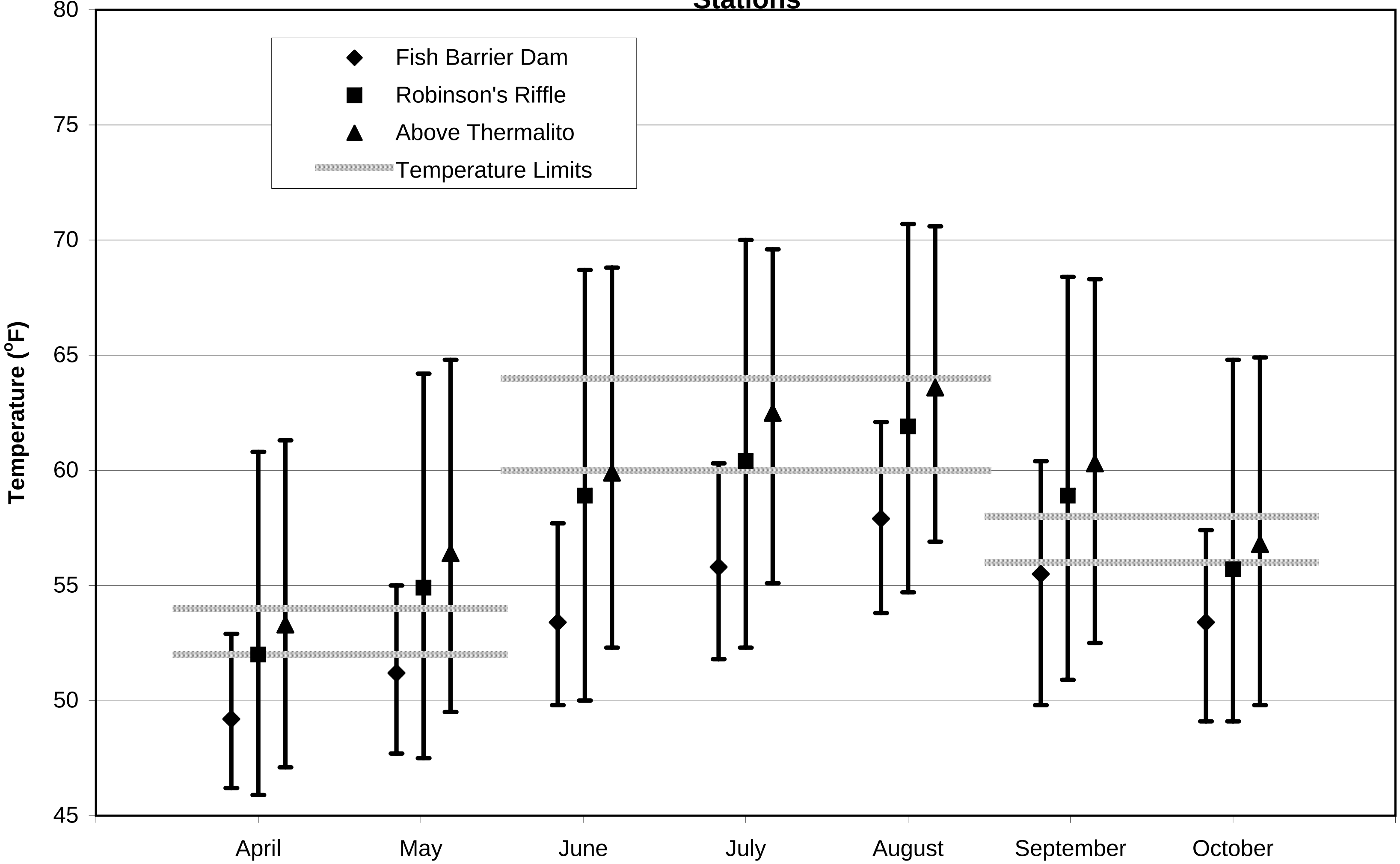
May through August that are suitable for shad, striped bass and other warmwater species.

- The amount of revenue that would be lost because of changes in power generation.

Cost Estimate:
The principle cost of this measure would be lost revenues associated with the changes in power generation (including reduced generation and changes in generation peaking). Additional costs would come from water temperature monitoring to evaluate the effectiveness of the measure and to ensure compliance with any new water temperature requirements.

Recommendations:
Before implementing this measure, additional information is needed from water temperature modeling simulations. These evaluations should provide useful insights on the feasibility of the measure in light of the potential conflicts and limitations.

Figure 1. Median of Daily Average, 95th Percentile of Daily Maximum, and 5th Percentile of Daily Minimum Water Temperatures for Benchmark Study Conditions; Low Flow Channel Stations



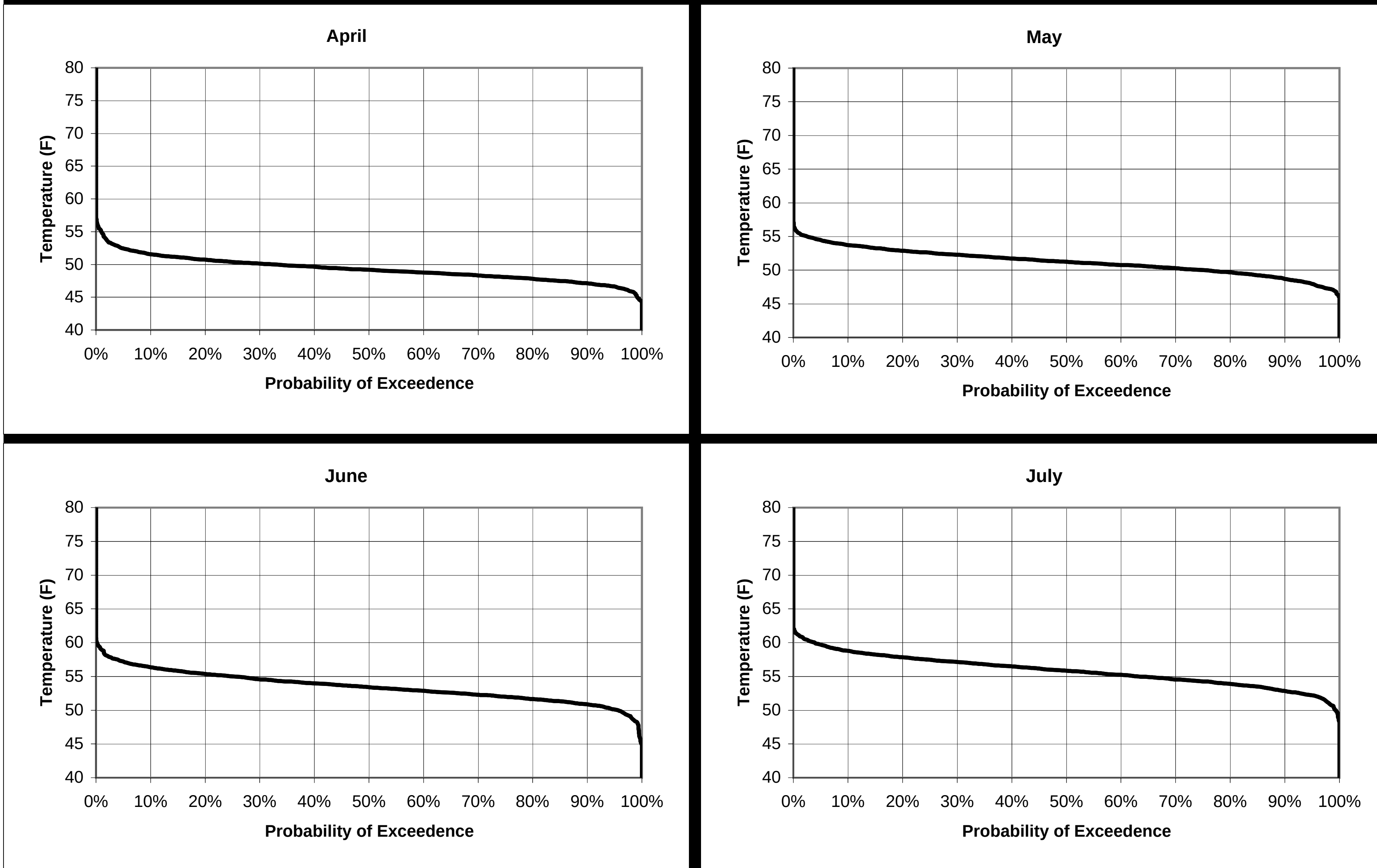


Figure 2. Daily Average Temperature Exceedence Curves for Existing Conditions Benchmark Study Results for the Feather River at the Fish Barrier Dam (April-November).

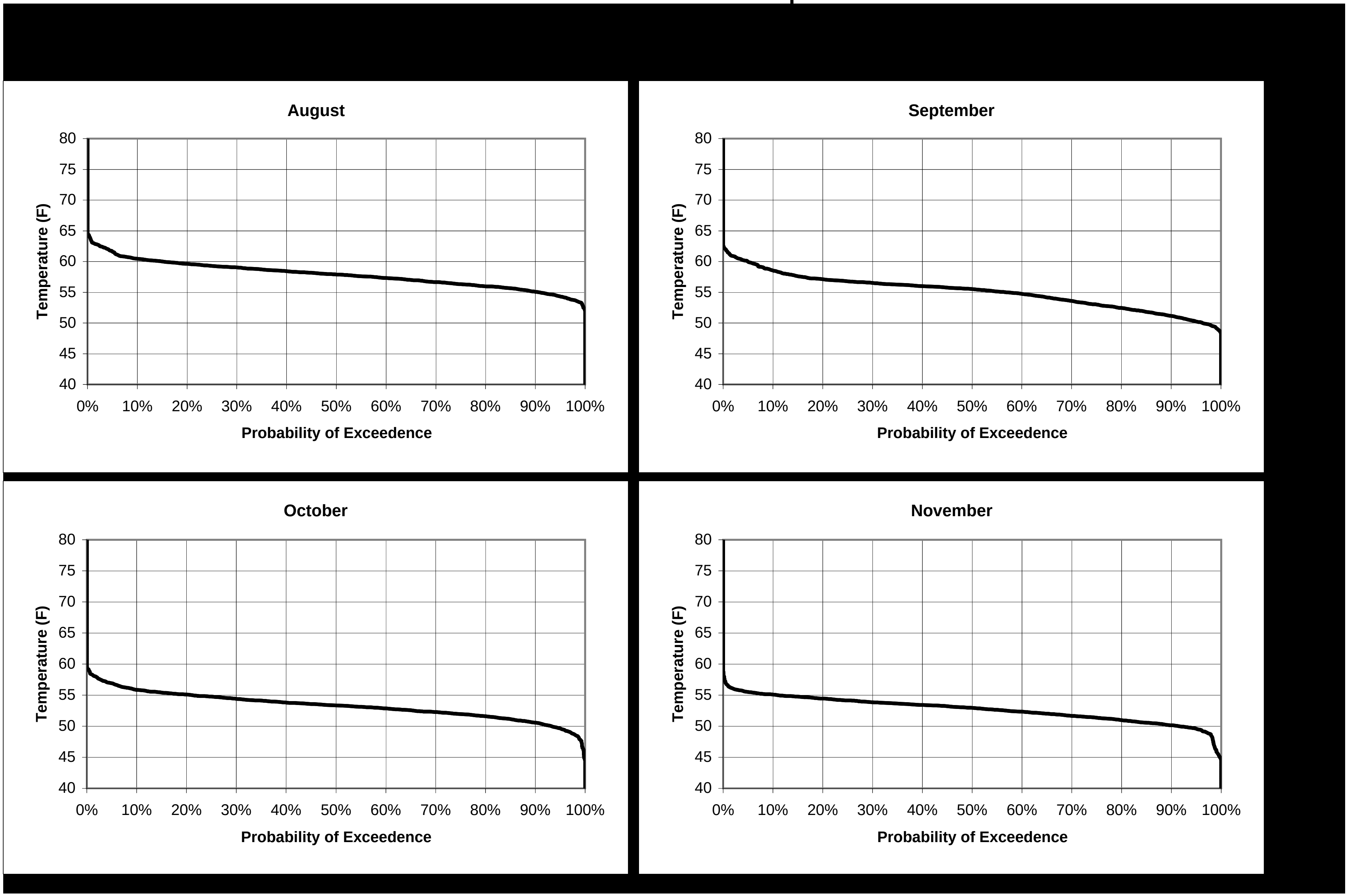


Figure 2. Daily Average Temperature Exceedence Curves for Existing Conditions Benchmark Study Results for the Feather River at the Fish Barrier Dam (April-November).

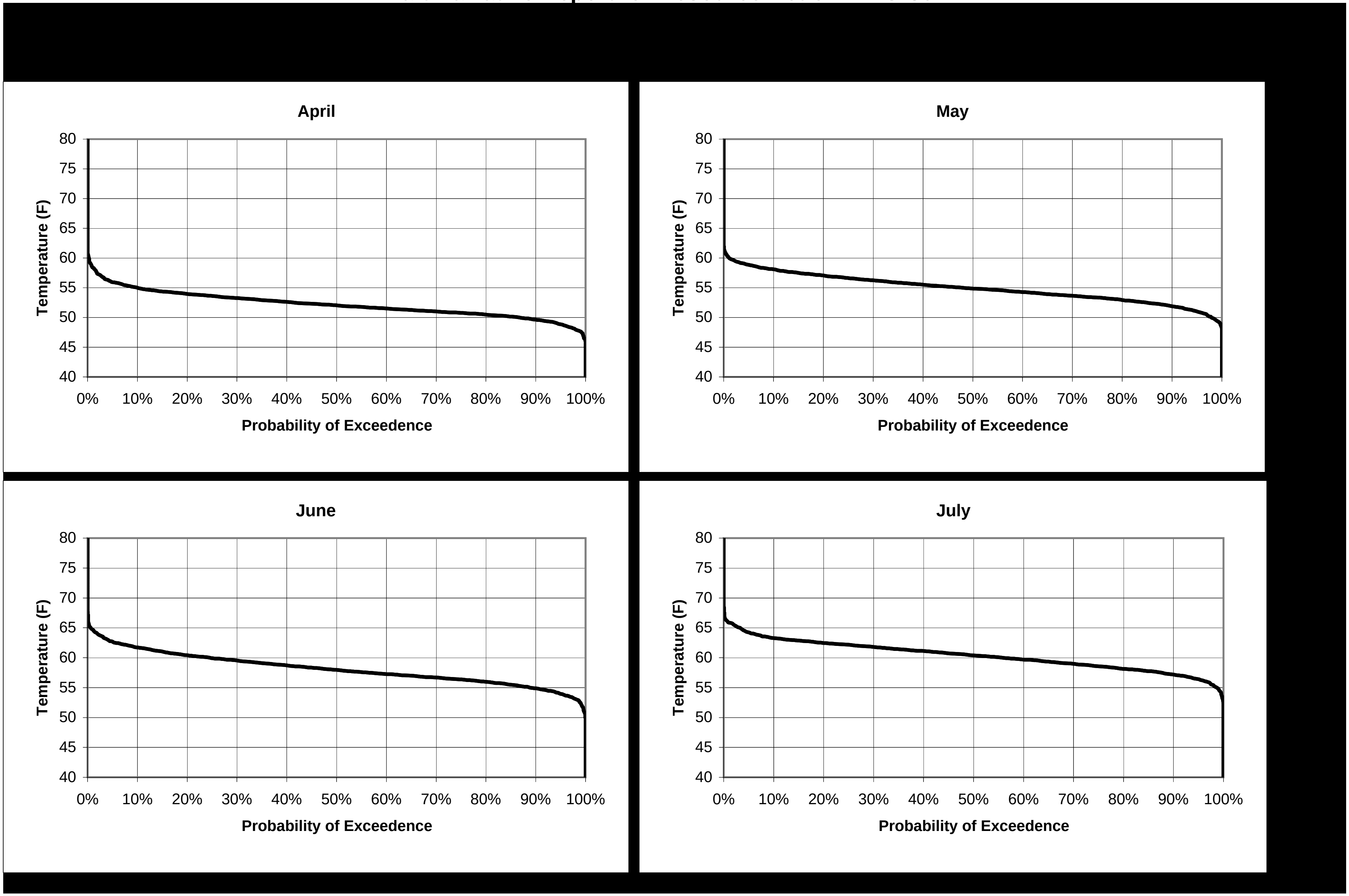


Figure 3. Daily Average Temperature Exceedence Curves for Existing Conditions Benchmark Study Results for the Feather River at Robinson's Riffle (April-November).

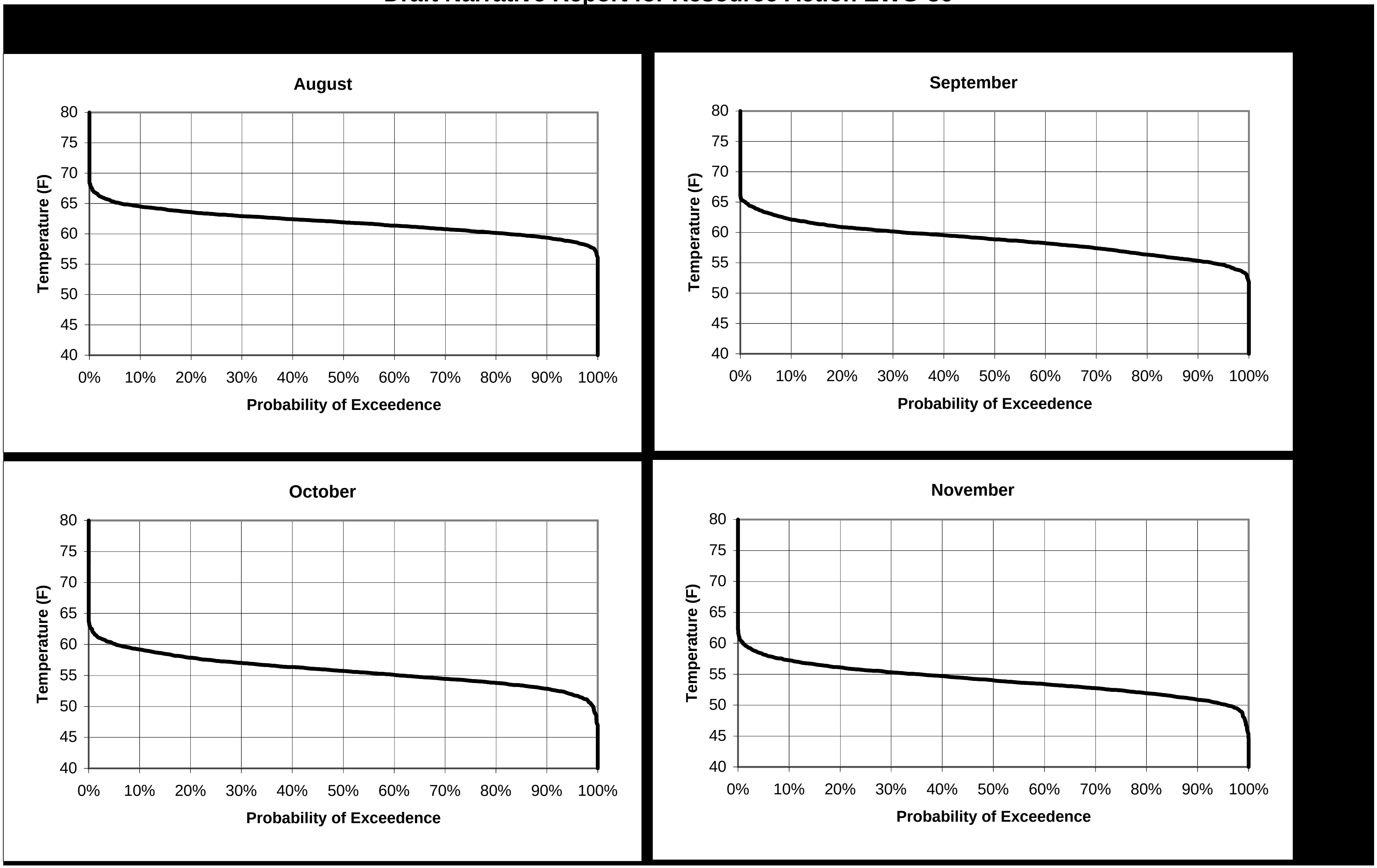


Figure 3. Daily Average Temperature Exceedence Curves for Existing Conditions Benchmark Study Results for the Feather River at Robinson's Riffle (April-November).

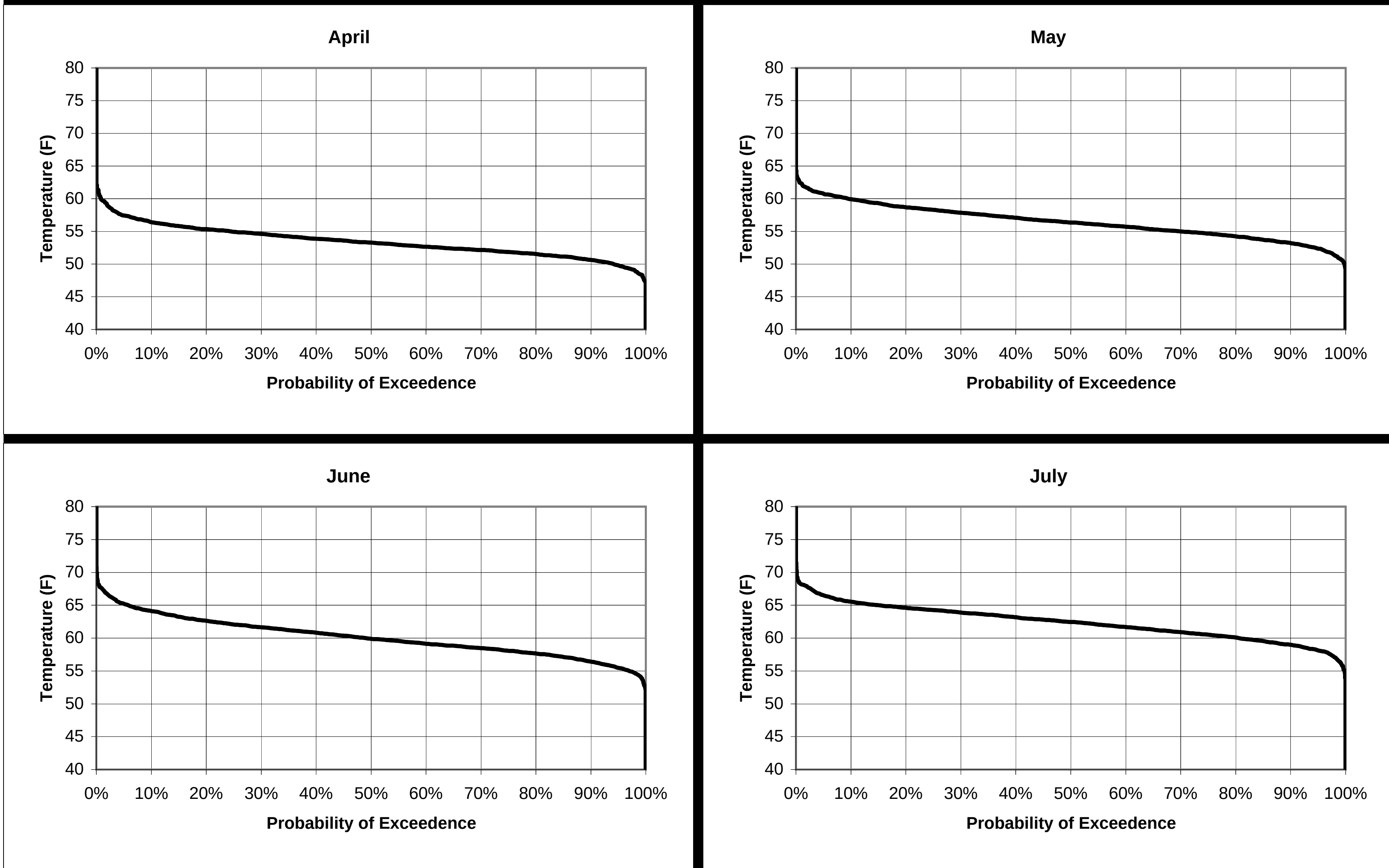


Figure 4. Daily Average Temperature Exceedence Curves for Existing Conditions Benchmark Study Results for the Feather River Above Thermalito (April-November).

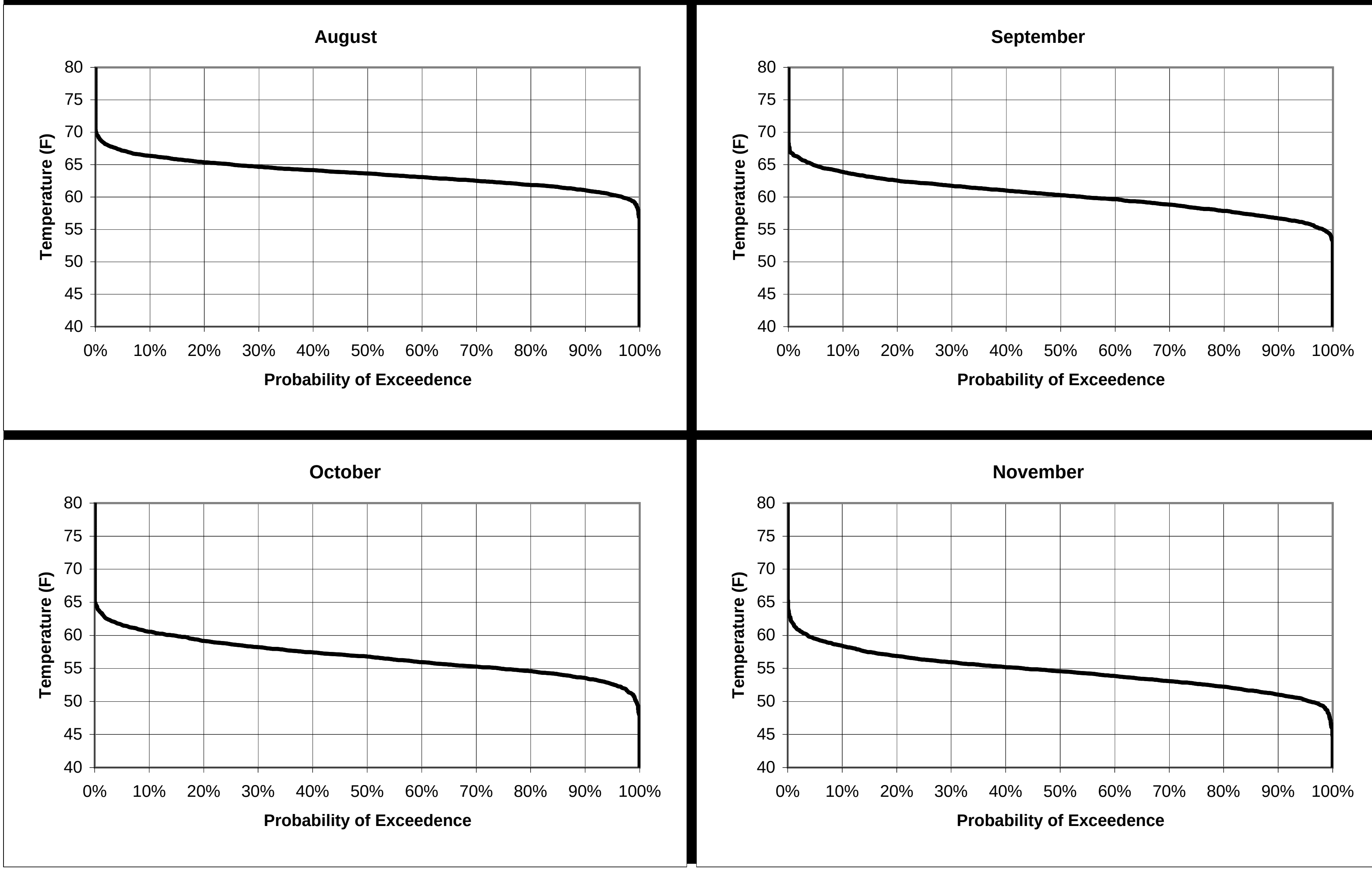
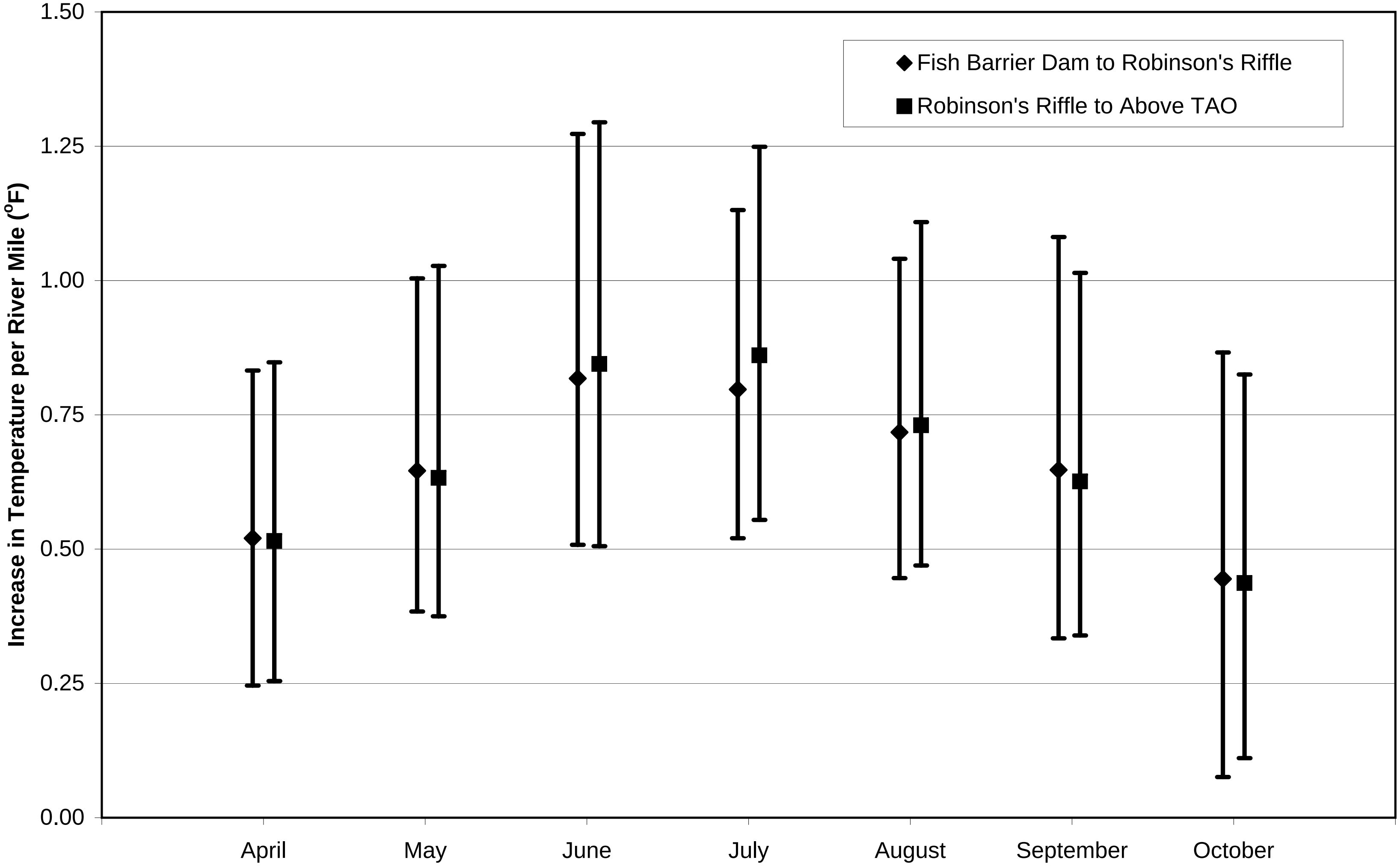


Figure 4. Daily Average Temperature Exceedence Curves for Existing Conditions Benchmark Study Results for the Feather River Above Thermalito (April-November).

Figure 5. Median, 95th Percentile, and 5th Percentile of Increases per River Mile in Average Daily Water Temperatures for Two Reaches of the Low Flow Channel of the Feather River



Resource Action: EWG-37	**Task Force Recommendation Category**: **2**

Operate the Oroville Facilities to Provide Additional Cold Water in the High Flow Channel of the Feather River for Benefit of Chinook Salmon and Steelhead

Related Resource Actions:

- EWG-27, which proposes to fill, modify, or isolate Robinson Riffle Borrow Pit.
- EWG-35A & EWG-35B, which propose to reduce rates of fish predation on juvenile salmonids by reducing water temperatures.
- EWG-36, which proposes to operate the Oroville Facilities in a manner that would provide colder water in low flow channel of the Feather River for benefit of Chinook salmon and steelhead.
- EWG-87, which proposes to modify the Thermalito Complex facilities in a manner to increase water temperatures in the Thermalito Afterbay and reduce temperatures in the Feather River downstream of the Afterbay outlet for beneficial uses.
- EWG-102, which proposes to provide water temperatures in the lower Feather River that mimic historic (pre Oroville Dam) to help maintain the genetic integrity of the spring-run Chinook salmon.

Date of Field Evaluation: No field evaluation was conducted

Evaluation Team: Phil Unger and David Sun

Description of Potential Resource Action Measure:
This measure would include structural changes and/or changes in operations of the Oroville Facilities to reduce water temperatures in the High Flow Channel of the Feather River (HFC) during certain times of year for the benefit of Chinook salmon and steelhead. The changes in operation would likely include releasing colder water from the reservoir and increasing releases to the Low Flow Channel (LFC). Proposed structural changes include constructing a canal to transport cold water directly from the Thermalito Pumping-Generating Plant tail channel to the southeastern portion of the Thermalito Afterbay, near the river outlet, thereby reducing the residence time of water in the Afterbay and reducing temperature of the water released into the river.

Nexus to the Project:
Water temperatures in much of the lower Feather River are strongly affected by operations of the Oroville Facilities. The Oroville Facilities allow project operators to regulate the depth in Oroville Reservoir from which water is released, the amount of water released from the reservoir into the river, the amount of water diverted from the LFC of the river through the Thermalito Complex, and the amount of water pumped back into the reservoir from the Thermalito Complex. These operational controls give

the operators various degrees of control over water temperatures in the LFC and the upper reaches of the HFC.

The 1983 agreement between the California Department of Water Resources (DWR) and California Department of Fish and Game (DFG), concerning the operation of the Oroville Division of the State Water Project for management of fish and game, established quantitative water temperature criteria for the lower Feather River. In this agreement, the Oroville Project is required to meet quantitative water temperature criteria at two downstream locations: the Feather River Hatchery (FRH) and the LFC at Robinson's Riffle (River Mile 61.6).

The water temperature criteria at the FRH and Robinson's Riffle are the principal water temperature targets controlling Oroville Project operations, but other water temperature objectives and goals occasionally influence project operations and potentially affect water temperatures in the HFC. The 1983 agreement established a narrative water temperature objective for the Feather River downstream of the Thermalito Afterbay outlet. This objective requires water temperatures downstream of the Thermalito Afterbay outlet that are suitable for fall-run Chinook salmon during the fall (after September 15) and suitable for shad, striped bass and other warmwater species from May through August. This narrative has no direct effect on operations because it is not well defined, but it has encouraged operators to seek opportunities to provide colder water to the HFC during the fall months.

An informal water temperature goal of the Oroville Facilities operators exists for the Thermalito Afterbay. This goal recognizes the need of local rice farmers for warm water temperatures during spring and summer for germination and growth of rice. Most of the rice farmers divert their irrigation water from the Thermalito Afterbay. Water temperature goals to support rice production are a minimum of 65°F during April through mid-May and a minimum of 59°F for the remainder of the growing season. Although DWR is not obligated to meet these goals, Project operators try to accommodate the rice farmers by releasing water as close as possible to the maximum temperature allowed under the FRH criteria. Because most of the water in the Thermalito Afterbay ultimately spills into the HFC of the Feather River, increases in Thermalito Afterbay water temperatures likely produce higher HFC water temperatures.

A recent evaluation conducted by the EWG fisheries technical team of Chinook salmon and steelhead water temperature needs in the Feather River suggests that under current Oroville Project operations, the water temperatures in the HFC of the Feather River are seasonally too warm for salmon and steelhead holding, spawning and rearing. Releases of water into the Feather River from the Thermalito Afterbay contribute substantially to the elevated water temperatures of the HFC.

Potential Environmental Benefits:
Based on recent water temperature conditions and the life histories of spring-run Chinook salmon and steelhead, this Resource Action would be most effective if implemented from April through October. This period includes the rearing period for spring-run Chinook salmon and steelhead and the immigration, holding and spawning period for spring-run and fall-run Chinook salmon.

The EWG fisheries team determined Chinook salmon and steelhead water temperature needs for each life-stage by synthesizing information obtained from the fisheries literature. Both fall-run and spring-run Chinook salmon spawn in the LFC beginning in early September. The upper reaches of the HFC have an abundance of suitable spawning gravels, but limited spawning occurs in the HFC because water temperatures are generally too warm. The EWG team determined that spawning and egg incubation water temperature requirements for Chinook salmon are no more than 56°F or 58°F (the two values reflect minor differences in the set of literature sources used for deriving the critical temperature estimates) (Table 1). Steelhead begin spawning about December, but continue spawning until approximately April, and egg incubation can continue through May. The EWG team determined that spawning and egg incubation temperature requirements for steelhead are 52°F and 54°F (again, the two values reflect differences in the set of literature sources used for estimates). Spring run adults hold in pools in the LFC from late spring through summer and fall run migrate upstream in late summer and hold more briefly. The EWG team determined that upstream migration and holding temperature requirements for adult spring-run and fall-run Chinook salmon are 60°F and 64°F (as before, the two values reflect differences in the set of literature sources used for estimates).

Life stage Activity/ Species or Run	Period	Upper Water Temperature Limit*
Spawning and Egg Incubation		
Spring-run Chinook	September – mid February	56°F & 58°F
Fall-run Chinook	September – mid February	56°F & 58°F
Steelhead	December - May	52°F & 54°F
Immigration and Holding		
Spring-run Chinook	March - October	60°F & 64°F
Fall-run Chinook	mid July - December	60°F & 64°F
Steelhead	September – mid April	52°F & 56°F

* Two values reflect minor differences in literature sources used to derive temperature limits.

Table 1. Months and Temperature Limits of Chinook Salmon and Steelhead Lifestages.

The suitability of water temperature conditions for Feather River salmon and steelhead was evaluated by comparing the water temperature limits in Table 1 to results of benchmark study water temperature modeling runs of existing (2001) conditions. The benchmark study simulates water temperatures at different locations based on current level-of-development hydrology and the current regulatory framework. The study estimates natural variability by using the 1922 through 1994 water year hydrology and meteorology for the water temperature simulations. Figures 1 through 3 present results of the study for two locations in the LFC: one location is 0.4 river miles upstream of the Thermalito Afterbay river outlet and the other is 13.1 river miles downstream of the outlet and just upstream of the Honcut Creek confluence. The Thermalito Afterbay outlet marks the upstream limit of the HFC. The analysis of water temperatures is limited to the HFC upstream of Honcut Creek because this portion of the HFC has the best spawning habitat conditions and because, realistically, modifications to the Oroville Facilities or their operations would be unable to affect water temperature further downstream. Figure 1 shows typical and extreme water temperatures for each location and month, as represented by the median of the daily average water temperatures, the 95^{th} percentile of the daily maximum water temperatures and the 5^{th} percentile of the daily minimum water temperatures. The figure also shows the most critical upper water temperature limits for each month, as described below. The results show that in all seven months, the median water temperature increases downstream from the Thermalito Afterbay outlet. Also, the median water temperatures at both HFC locations increase from April through August, and then decline. Figures 2 and 3 provide exceedance plots for daily average water temperatures in April through November at the two HFC locations.

Table 2 gives the frequencies, as percentages, that the salmon and steelhead water temperature limits are exceeded for each month from April through November at each of the HFC locations. These results are based on the temperature limits in Table 1 and the exceedance data in Figures 2 and 3. For each month from April through November, Table 2 gives the species/life history stage activity with the most restrictive (coldest) water temperature limits, the two water temperature estimates of those limits from Table 1, and the percentage of days during each month that the daily average water temperature exceeds each limit. These percentages are provided for the two locations in the HFC; downstream of the Thermalito Afterbay river outlet and upstream of Honcut Creek. For September, October and November, the temperature limits and exceedance frequencies are provided for two species/life stage activities, spring-run and fall-run salmon spawning and egg incubation and steelhead immigration and holding. Although steelhead immigration and holding has colder water temperature requirements than salmon spawning and egg incubation, the latter are considered to be more critical because of the greater sensitivity of spawning and egg incubation to unsuitable water temperature conditions.

Month	Limiting Species/Life Stage*	Upper Temperature Limits (^oF)**	Frequency of Exceeding Limits (%)	
			Below TAO	Above Honcut
April	SH S&E	52 and 54	87 and 53	95 and 84
May	SH S&E	52 and 54	97 and 88	99 and 96
June	SR I&H	60 and 64	63 and 16	93 and 53
July	SR & FR I&H	60 and 64	84 and 31	98 and 70
August	SR & FR I&H	60 and 64	99 and 63	100 and 94
September	SR & FR S&E; SH I&H	56 and 58; 52 and 56	100 and 97; 100 and 100	100 and 100; 100 and 100
October	SR & FR S&E; SH I&H	56 and 58; 52 and 56	90 and 68; 98 and 90	100 and 85; 100 and 96
November	SR & FR S&E; SH I&H	56 and 58; 52 and 56	50 and 23; 75 and 50	90 and 42; 90 and 61

* SH=steelhead, SR=spring-run chinook, FR=fall-run chinook, S&E=spawning and egg incubation, I&H=immigration and holding
** Two values reflect minor differences in literature sources used to derive temperature limits.

Table 2. Frequencies of Exceeding Temperature Limits of Limiting Species/Life Stage during each Month based on Benchmark Study Simulation Results

With few exceptions, the results in Table 2 show that the temperature limits are usually exceeded in every month at both locations in the HFC. The lower temperature limit for Chinook salmon immigration and holding is exceeded less than half of the days in June and July at the location just downstream of the Thermalito Afterbay outlet, and the lower temperature limit for salmon spawning and egg incubation is exceeded less than half of the days in November at both HFC locations. However, in all other months and locations, the temperature limits are exceeded at least half of the time, and in many months and locations they are exceeded more than 90 percent of the time.

It should be noted that the frequencies of occurrence are not equivalent to probabilities because water temperatures on a given day are not independent events, but rather tend to be related to temperatures on neighboring dates. As a result, water temperatures of a month within a year tend to be more similar than those of the same month in other years. This is significant because it means that the probability of exceeding a temperature limit every year is actually somewhat lower than suggested by the frequencies in Table 2. Nevertheless, the results clearly indicate that reducing water temperatures in the HFC would benefit salmon and steelhead. As shown in Figure 1, the median water temperatures at the HFC locations substantially exceed the temperature limits in many of the months, indicating that fairly large reductions in water temperatures are needed.

Potential Constraints:
As previously noted, this Resource Action would likely include releasing colder water from Oroville Reservoir and/or increasing flow releases to the LFC. However, several important potential constraints could limit these changes in operations.

A major potential constraint is the need to maintain current Oroville Project contributions to the statewide water supply. The Oroville Project is one of many water projects coordinated to meet California's water supply needs. Releases from the different storage reservoirs of the State Water Project and Central Valley Project are carefully managed in a coordinated fashion to satisfy irrigation, municipal and environmental demands without unduly risking future supplies. The amount of water released from Oroville Reservoir cannot be substantially altered without disrupting this system. Increasing Oroville Project deliveries at one time would generally require reductions in deliveries at other times, and such reductions could be mitigated only by requiring other water projects to increase their deliveries or by reducing demand. The Oroville Project cannot reduce demand or alter the delivery schedules of other water projects. If the total releases from the Oroville Facilities cannot be changed, water temperatures in the HFC can be reduced only by varying the proportion of flow reaching the HFC that passes through the LFC versus the Thermalito Complex, by releasing colder water from the reservoir, or by structural modifications of the Thermalito Afterbay.

Substantially increasing the proportion of flow directed through the LFC is constrained by habitat considerations. Instream flow studies of fish habitat (PHABSIM) indicate that the availability of spawning habitat for chinook salmon and steelhead in the LFC are maximized at a flow of about 800 cfs. Therefore, HFC water temperature benefits potentially gained by increasing LFC flow above 800 cfs could be offset by LFC reductions in habitat availability.

Another major constraint on this Resource Action is the limited volume of Oroville Reservoir's cold-water pool. The limited volume of cold water in the reservoir restricts how much and for how long water temperatures in the HFC could be reduced. This constraint would be particularly significant in dry and critically dry water type years. Also, releasing very cold water would adversely affect egg development and growth of juvenile salmonids in the LFC and the FRH. Note that the FRH water temperature criteria limit the amount of reduction in water temperatures that are allowed to be released from Lake Oroville.

Another important constraint is the loss of power generation through the hydroelectric facilities that would potentially accompany implementation of this measure. Operations that can be used to reduce water temperatures in the HFC include increasing flow releases to the LFC, reducing pump-back and peaking operations, and opening the Oroville Dam river valve (the least desirable option). These actions would typically result in varying degrees of losses in hydroelectric power generation.

This measure could also be constrained by regulatory requirements. A narrative objective for water temperatures in the Feather River below the Thermalito Afterbay river outlet requires water temperatures that are suitable for shad, striped bass and other warmwater species from May through August. Reducing spring and summer water temperatures in the HFC could make it difficult to meet this objective. Measures to reduce water temperatures in the HFC are also potentially constrained by the goal to supply rice farmers with warm water during spring and summer and by the goal to provide suitable warm water for recreation activities.

Existing Conditions in the Proposed Resource Action Implementation Area:
The portion of the lower Feather River that is the focus of this Resource Action is the upstream section of the HFC, extending about 14 miles from the Thermalito Afterbay outlet to Honcut Creek. The minimum flows and the water temperature targets in the HFC are established by a 1983 agreement between DWR and DFG. The instream flow requirements are 1,700 cfs from October through March and 1,000 cfs from April through September for wetter years (> 55% of normal runoff), and 1,200 cfs for October through February and 1,000 cfs for March through September for drier years. As previously described, the water temperature must be suitable for fall-run Chinook salmon after September 15, and they must be suitable for shad, striped bass, and other warmwater species, from May through August.

Spring and summer water temperatures in the HFC are typically warmer than those in the LFC in large part because of the large volumes of relatively warm water released to the HFC from the Thermalito Afterbay outlet. Water temperatures in the Thermalito Afterbay are relatively high because water moves more slowly through the Thermalito Complex, and especially the Afterbay, than through the LFC and is subject to greater atmospheric warming. The contribution of the Thermalito Afterbay outlet inflow to the total flow of the HFC is typically greater than that of the LFC flow.

The releases of large flows with relatively high water temperatures from the Thermalito Afterbay outlet typically results in a sharp thermal gradient from the downstream end of the LFC to the upstream end of the HFC. Water temperatures in the HFC just downstream of the Afterbay outlet are often several degrees warmer than temperatures in the lower part of the LFC (upstream of Thermalito Afterbay outlet), particularly in the late spring and early autumn.
Beyond the influence of the Thermalito Afterbay outlet, downstream warming in the HFC is relatively low, at least as compared to that in the LFC. Figure 4 shows rates of warming in the HFC, the LFC, and the transition between the LFC and HFC. The rates are expressed as increases in temperature per river mile. The Figure shows warming for one reach in the HFC, from the location 0.4 river miles downstream of the Afterbay outlet to that just upstream of Honcut Creek (12.7 river miles), and for two reaches in the LFC, from the Fish Barrier Dam to Robinson's Riffle (5.55 river miles), and from Robinson's Riffle to a site 0.4 miles upstream of the Thermalito Afterbay outlet (2.3 river miles). The transition reach is from the site upstream of the Afterbay outlet to that

downstream of the outlet (0.8 river miles). Figure 4 shows that rates of warming are relatively low and quite consistent from April through October in the HFC. Warming rates are generally higher in the LFC reaches, especially in the summer months. The reduced warming rate in the HFC is attributable to its higher flows and to the fact that the HFC water temperatures are usually more nearly in equilibrium with atmospheric temperatures than the LFC water temperatures. Rates of warming in the transition reach are often very high and highly variable because of the effect of the Thermalito Afterbay releases. These rates are especially high in spring and fall. In July, however, the warming rate in this reach is almost as low as that in the HFC.

Design Considerations and Evaluation:
As previously indicated, some measures to significantly reduce water temperatures in the HFC would potentially affect habitat conditions in the LFC adversely.

Engineering and Operations water temperature modelers are currently evaluating effects of different project operations on water temperatures in the LFC and HFC. Results of the modeling simulations will be used to develop specifics of how project operations could be modified to implement this Resource Action.

Implementing this Resource Action by modifying the conveyance system for water entering the Thermalito Afterbay would involve a number of complex design considerations. These are addressed in the EWG-87 narrative, which more directly addresses water temperature conditions in the Thermalito Afterbay.

The effectiveness of this measure would be evaluated by comparing water temperatures measured at several locations in the lower Feather River before and after implementing the measure. The comparisons would use water temperature modeling to adjust for differences in atmospheric conditions and other potentially confounding variables in making the comparisons. Water temperature data currently being collected in the lower Feather River will provide the information on water temperatures before implementing any changes in project operations.

Synergisms and Conflicts:
This Resource Action is compatible with Resource Actions EWG-36 and EWG-102, which share with EWG-37 the resource goal of providing desirable water temperatures for coldwater fish. By benefiting coldwater fishes, the Resource Action would likely enhance recreation in the HFC, providing increased summer angling opportunities for trout and Chinook salmon. This Resource Action would likely reduce the steep thermal gradient between the HFC and the LFC and thereby improve upstream passage and habitat conditions for anadromous salmonids, which are resource goals of many of the proposed resource actions. The colder water that would result from this measure might also help reduce predation on juvenile salmonids because the colder water would reduce metabolic rates of the fish predators in the HFC, and thereby potentially reduce their feeding rates. Reduced predation on juvenile salmonids is the resource goal for Resource Actions EWG-35A, EWG-35B and EWG- 27.

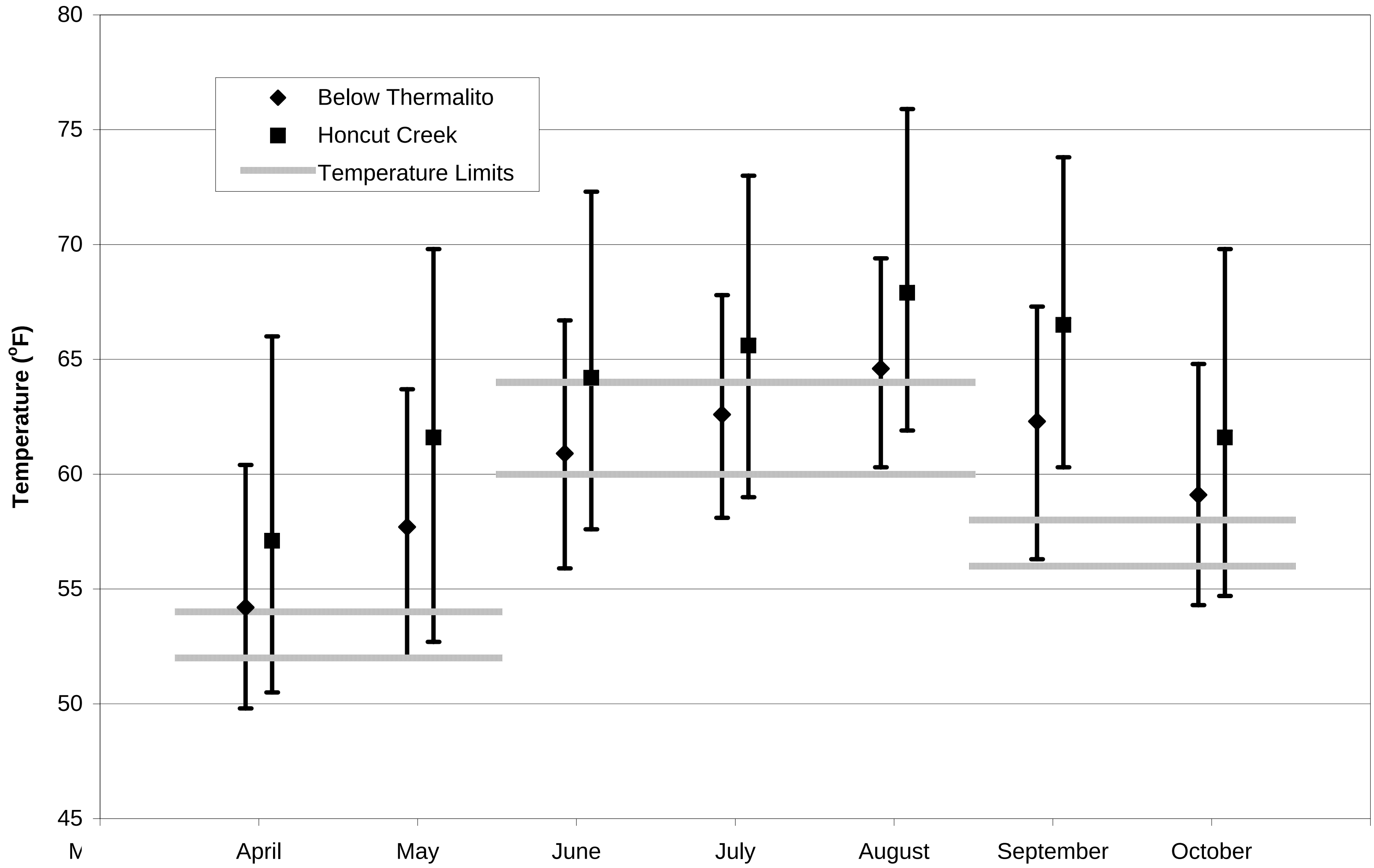
This Resource Action would potentially conflict with a number of resource goals. These include providing warmer water to Thermalito Afterbay for agriculture (e.g., EWG-87), increasing production of coldwater fishes in the reservoir, and enhancing water-contact recreational opportunities in the lower Feather River. However, to the extent that more water is diverted through the LFC rather than through the Thermalito Complex, or that the cold water entering the Thermalito Afterbay is conveyed more directly to the Thermalito Afterbay outlet, this Resource Action also has the potential to allow warmer waters for agricultural diversion from the Thermalito Afterbay (EWG-87). Depending on the methods used to reach desired water temperatures, this Resource Actioncould also have considerable costs in terms of lost power generation.

Uncertainties:
Important uncertainties related to this Resource Action include:
- Whether the amount of water in Oroville Reservoir's cold-water pool during dry and/or critically dry years would be sufficient to effect the proposed reductions in water temperatures, particularly during late summer and fall, and how a reduction in the volume of the cold-water pool would affect the cold-water fisheries of the reservoir. Whether the Resource Action could be implemented without adversely affecting salmonids in the LFC.
- Whether the Resource Action could be implemented without conflicting with DWR agreements or goals, including the FRH water temperature criteria, the agreement to accommodate water temperature needs of rice farmers, and the agreement to provide water temperatures downstream of the Thermalito Afterbay outlet from May through August that are suitable for shad, striped bass and other warmwater species.
- The amount of revenue that would be lost because of changes in power generation.

Cost Estimate:
The principle costs of this measure would be construction costs associated with modifying the conveyance system for water entering the Thermalito Afterbay and lost revenues associated with the changes in power generation (including reduced generation and changes in generation peaking). Additional costs would come from water temperature monitoring to evaluate the effectiveness of the measure and to ensure compliance with any new water temperature requirements.

Recommendations:
Before implementing this measure, better information is needed from water temperature modeling simulations. These evaluations should provide useful insights on the feasibility of the measure in light of the potential conflicts and limitations.

Figure 1. Median of Daily Average, 95th Percentile of Daily Maximum, and 5th Percentile of Daily Minimum Water Temperatures for Benchmark Study Conditions; High Flow Channel Stations



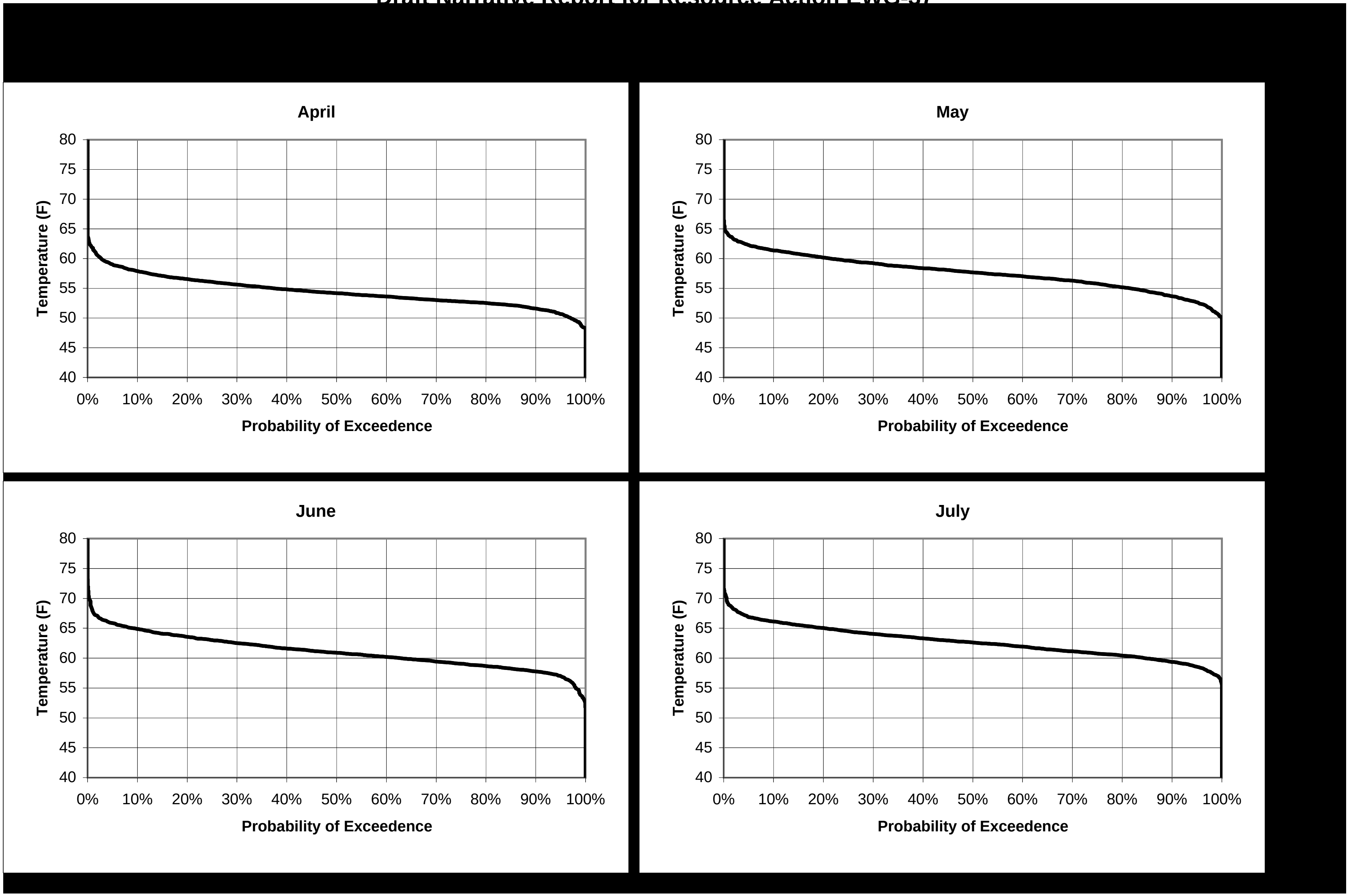


Figure 2. Daily Average Temperature Exceedence Curves for Existing Conditions Benchmark Study Results for the Feather River Below Thermalito (April-November).

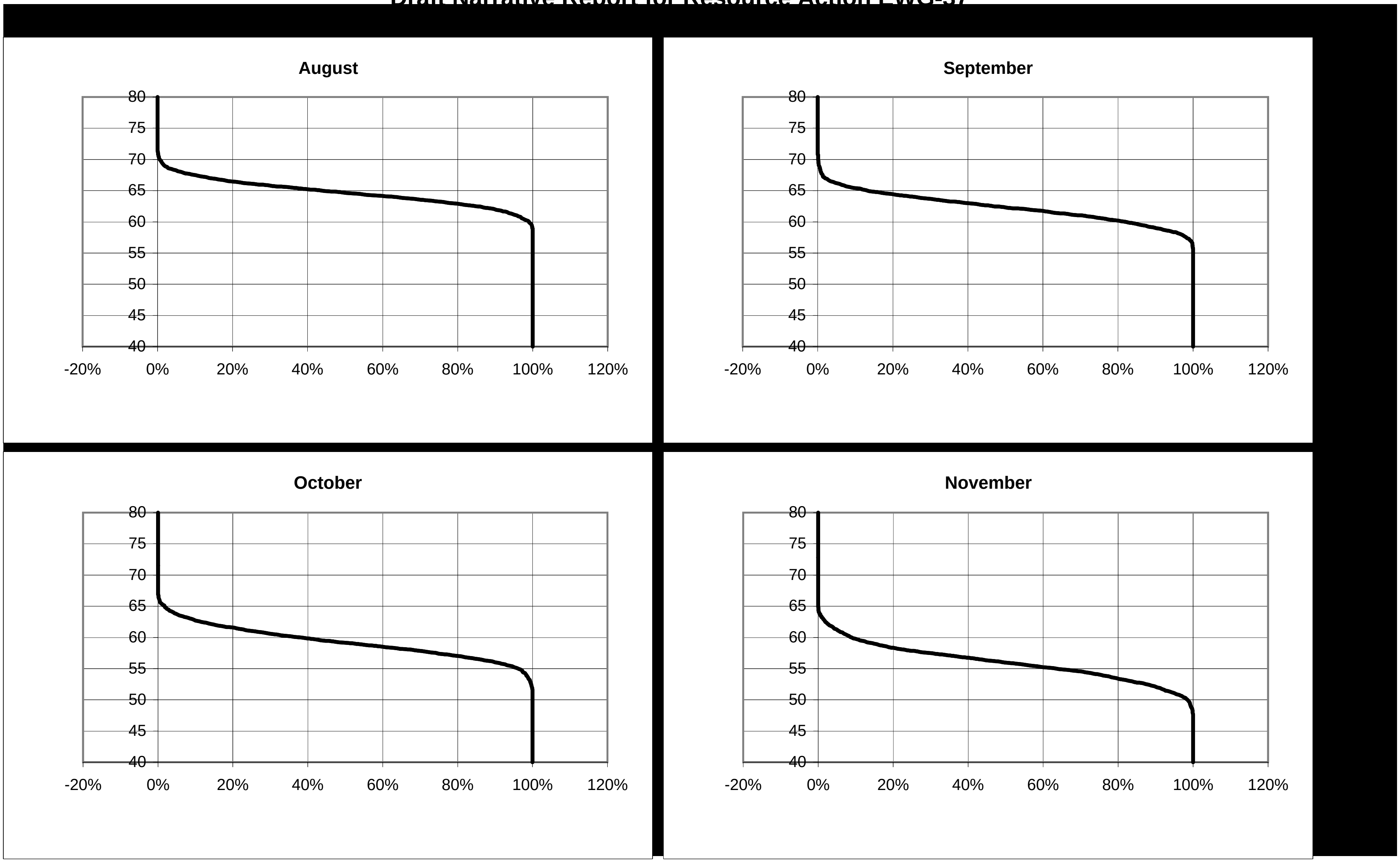


Figure 2. Daily Average Temperature Exceedence Curves for Existing Conditions Benchmark Study Results for the Feather River Below Thermalito (April-November).

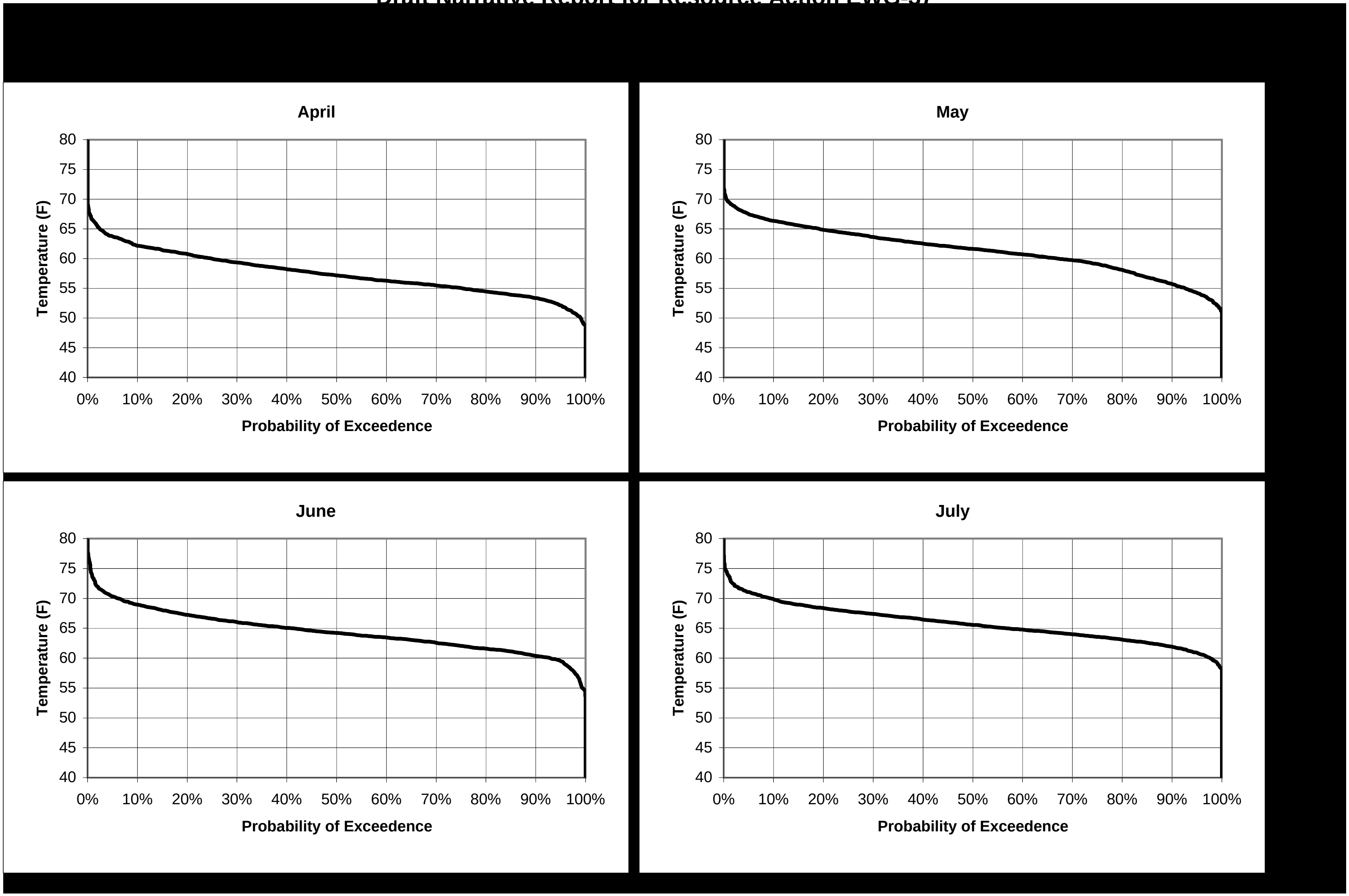


Figure 3. Daily Average Temperature Exceedence Curves for Existing Conditions Benchmark Study Results for the Feather River Above Honcut Creek (April-November).

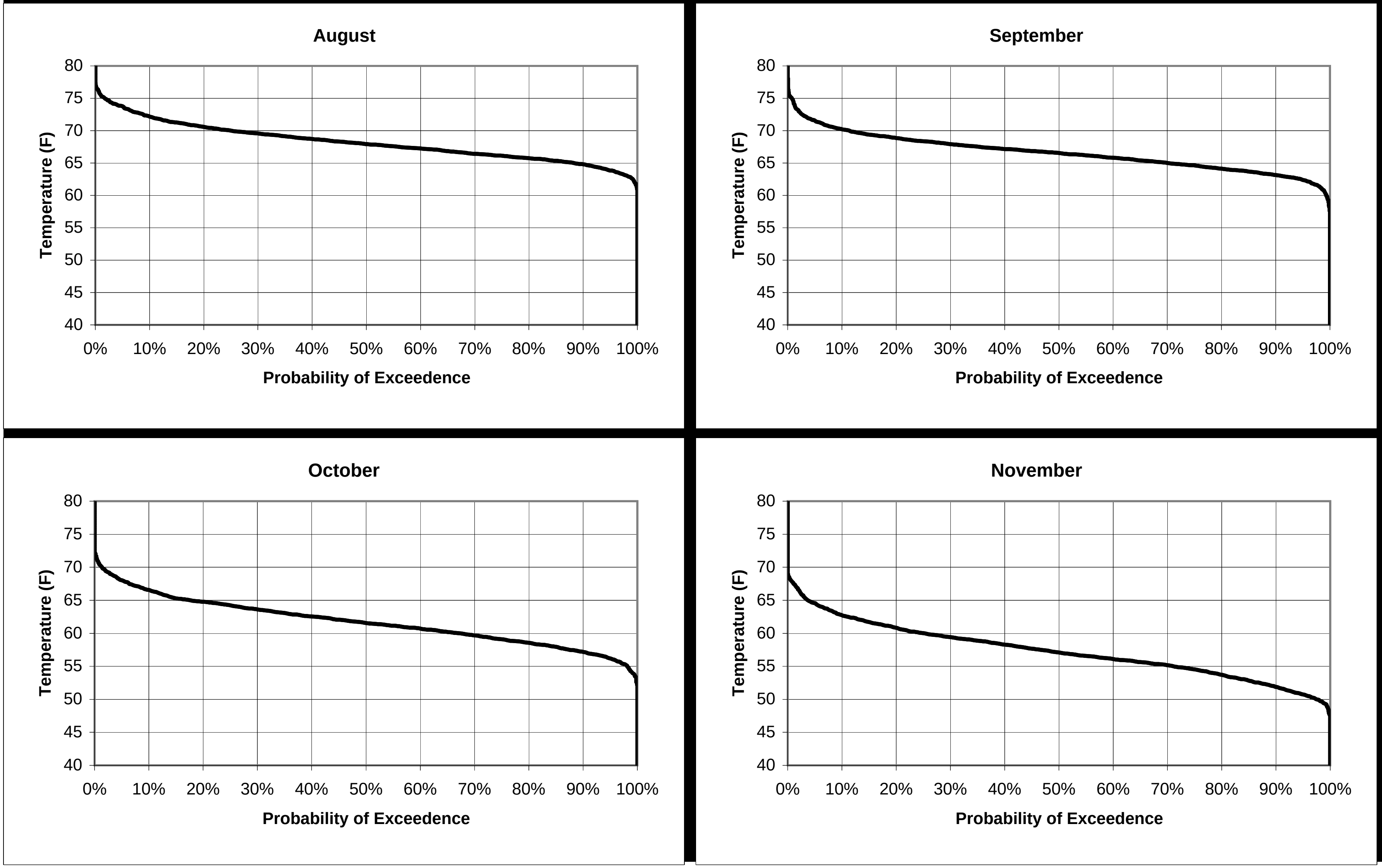
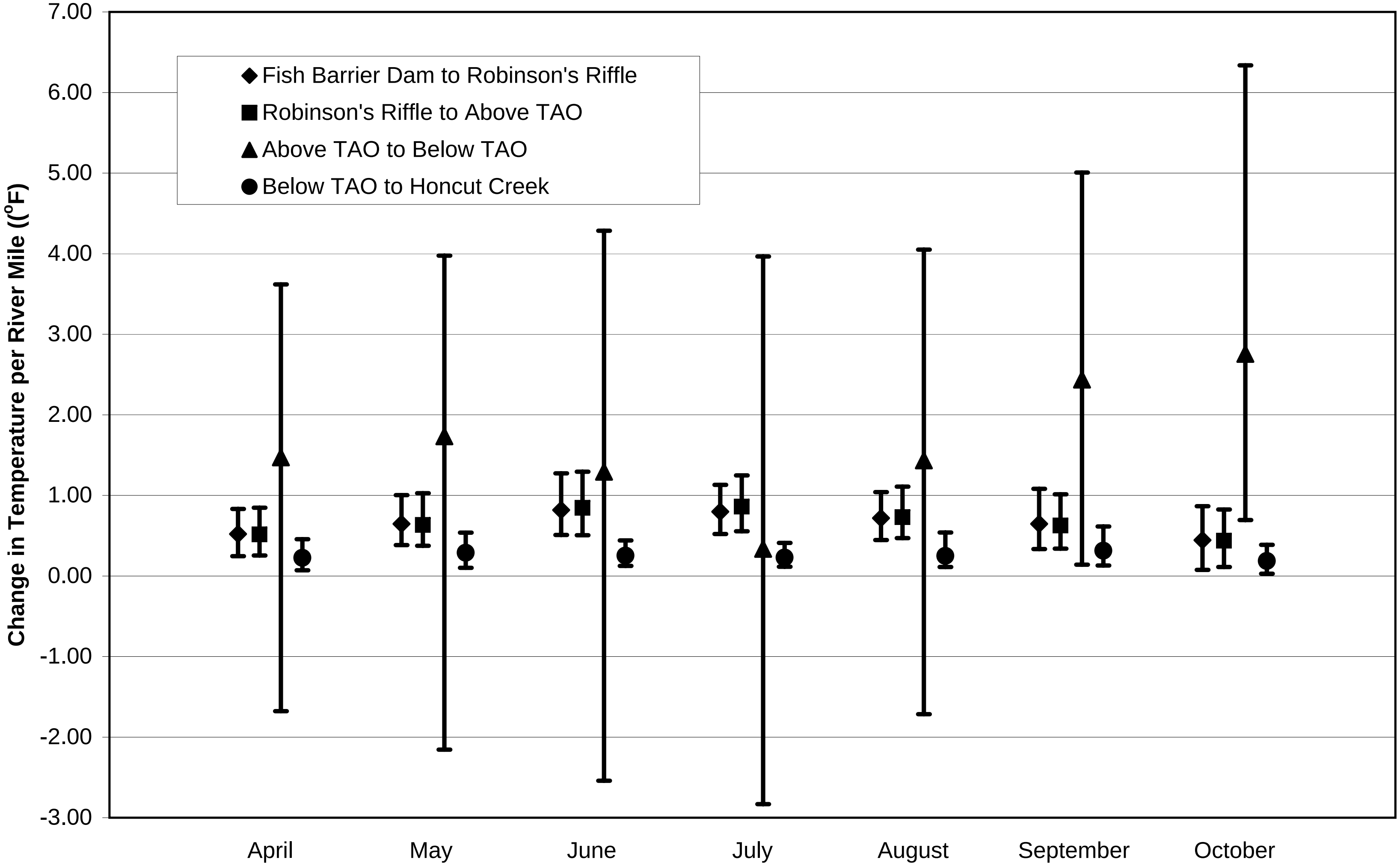


Figure 3. Daily Average Temperature Exceedence Curves for Existing Conditions Benchmark Study Results for the Feather River Above Honcut Creek (April-November).

Figure 4. Median, 95th Percentile, and 5th Percentile of Increases per River Mile in Average Daily Water Temperatures for Four Reaches in the Lower Feather River



Resource Action: EWG-59	**Task Force Recommendation Category:** 2

MODIFY RECREATION USE PATTERNS AT THE THERMALITO FOREBAY AND THERMALITO AFTERBAY TO MINIMIZE ADVERSE AFFECTS TO SENSITIVE WILDLIFE SPECIES

Date of Field Evaluation: February 2002 through March 2004

Field Evaluation Team: Dave Bogener

Description of Potential Resource Action:

This Resource Action contains two actions designed to minimize or avoid recreational impacts to sensitive wildlife species or sensitive life stages including vernal pool invertebrates and nesting waterfowl.. Relicensing studies have identified potentially adverse impacts associated with;

- Off-Road Vehicle (ORV) use in vernal pool habitats at the Thermalito Afterbay and Forebay
- Recreational disturbance of upland habitats around the Thermalito Afterbay during the waterfowl nesting season

ORV impacts to vernal pool habitats can degrade habitat for three invertebrate species protected under the federal Endangered Species Act. Of the 253 vernal pools identified within the project boundary, about 23 percent currently exhibit degradation due to ORV use. ORVs can damage vernal pools by disruption of overland flow patterns and from direct habitat destruction. The weight of vehicles can crush or displace fairy and tadpole shrimp when present during the wet season or destroy eggs or cysts in the summer. The compacted soils in the resulting tire ruts are unsuitable for sustainability of the vernal pool ecology, affecting the growth of aquatic plants and algae. During federal Endangered Species Act Section 7 consultation process, DWR and USF&WS identified several conservation measures to minimize ORV impacts on vernal pool habitats including; area vehicular closures, signage, patrol, enforcement, and barrier maintenance.

DFG currently limits recreational use of waterfowl nesting habitats around the Thermalito Afterbay between March 15 and June 15 to minimize disturbance and associated abandonment or predation of waterfowl nests or young. This Resource Action is a continuation of this existing seasonal closure. Relicensing evaluations indicate that additional protective measures (beyond these seasonal closures) are not currently required to limit recreational disturbance of nesting waterfowl.

Nexus to Project:

The Thermalito Afterbay and Forebay support significant recreational use on a year-round basis. Recreational facilities and uses are generally compatible with wildlife management objectives. However, to ensure federal Section 7 ESA compliance additional conservation measures are required to protect vernal pool habitats.

DFG manages lands around the Thermalito Afterbay in support of the goals and objectives of the Central Valley Joint Habitat Venture, a regional program to improve waterfowl habitat and production. DWR is also a signatory to the CVJHV.

Potential Environmental Benefits:

Implementation of conservation measures to limit ORV use in vernal pool habitats would serve to limit soil erosion or compaction and associated vegetative disturbance in the vernal pool habitats and adjacent uplands. These basic resource protection measures would serve to minimize resource degradation and maintain or enhance habitat diversity, a key component of wildlife species diversity.

Seasonal recreational closure of waterfowl nesting areas around the Thermalito Afterbay would serve to maintain current levels of waterfowl production. Furthermore, these seasonal recreational closures limit impacts on other wildlife species including several State or federal Species of Concern (northern harrier, black-shouldered kite, loggerhead shrike, burrowing owl, short-eared owl, western pond turtle, double-crested cormorant, black-crowned night heron, American bittern, osprey, California horned lark, yellow warbler, and tri-colored blackbird).

Potential Constraints:

Limiting future use of ORVs in vernal pool areas may prove difficult as virtually all of the resource damage observed occurred in areas already closed to ORV use. No loss of legal recreational ORV use will occur as a result of this Resource Action.

Continuation of the existing seasonal recreational closure around the Thermalito Afterbay will not restrict recreational use beyond historic levels..

Existing Conditions in the Proposed Resource Action Implementation Area:

About 253 vernal pools totally 18.3 acres are present within the FERC project boundary. Detailed mapping of vernal pool locations is presented in Relicensing Study Report T-2 (DWR 2004b). Over half of the pools occur in two clusters located near the south end of Wilbur Road or near the South Thermalito Forebay boat ramp. Indications of ORV damage to vernal pools was identified at 57 pools (22.5 percent). State lands are currently fenced, posted, and patrolled to limit ORV use and resource damage. Cutting of the boundary fence to facilitate illegal ORV entry onto State lands is perceived as the principal entry point for illegal ORV use.

DFG has historically planted an average of 60 to 70 acres of waterfowl nest cover enhancement plots in upland areas around the Afterbay. These plantings can provide suitable nesting cover for several years with annual fertilization. As much as 300 acres may be in suitable nesting cover during any nesting season. These habitat improvement plots are widely scattered throughout the more upland areas surrounding the Afterbay. Areas immediately adjacent to Afterbay (within 200 feet) are rarely planted as the soils are generally to moist to allow equipment access.

Design Considerations and Evaluation:

Conservation measures developed in coordination with USF&WS for the protection of vernal pool habitats include;

- Regular inspection of boundary fence lines in areas containing vernal pools and timely repair of damaged fences to limit ORV access.
- Public educational signage in closed areas.
- Regular patrol and enforcement of vernal pool areas to restrict ORV use.
- Placement of additional fencing or barriers to further restrict ORV access to vernal pools as needed.
- Annual inspection of vernal pools to evaluate the success of conservation measures
- Annual reporting of resource damage to vernal pool habitats.

Seasonal closure of waterfowl nesting areas requires signage at major public access points and near nest cover enhancement plots. Signage should inform/educate the public on the reasons for the closure and the temporal extent of the closure (March 15 through June 15). Further, patrol and enforcement are required to effectively implement seasonal closures. This is ongoing resource protection measure that has proven successful at limiting recreational disturbance of nesting waterfowl and other wildlife species.

Synergism and Conflicts:

The Resource Action related to minimization of ORV damage to vernal pool habitats will work synergistically with other conservation measures developed in cooperation with USF&WS to avoid or minimize adverse affects to vernal pool habitats including

- Abandon and revegetate all roads (in vernal pool areas) which are no longer required for project operations or maintenance
- Gravel existing unpaved roads to limit sedimentation into vernal pools

- Construct and evaluate several sediment trapping methods to limit sediment discharge from roads into vernal pools
- Design and conduct earthmoving activities to limit sediment discharge into vernal pools
- Limit soil disturbance within 100 feet of vernal pools
- Limit, to the extent practicable, use of pesticides within 200 feet of vernal pools
- Periodically inspect vernal pools to evaluate the success of conservation measures
- Annually report to USF&WS on the success of conservation measures.

This Resource Action is designed to limit currently illegal ORV use and would conflict with any recreation related Resource Action which require additional public vehicular access in areas containing vernal pools.

DFG, DWR, and the California Waterfowl Association have worked cooperatively over the last 15 years to improve waterfowl habitat and production within the Afterbay portion of the Oroville Wildlife Area. This Resource Action will work synergistically with several other waterfowl related Resource Actions to improve waterfowl habitat and production including;

- EWG-56 brood pond construction
- EWG-68A brood pond recharge
- EWG -57A waterfowl nest cover enhancement
- EWG 58A wood duck nest box program
- EWG 57B Waterfowl forage enhancement

This Resource Action could conflict with recreation related Resource Actions which advocate additional recreational development o spring recreational use of upland areas around the Afterbay.

Uncertainties:

A high degree of uncertainty of success exists related to protection of vernal pools from ORV damage. Public education/signage will serve to inform the public of area vehicular closure. However, regular patrol, enforcement, and fence maintenance will be required to limit ORV entry into closed areas. If illegal ORV use and entry cannot be prevented through these means, adaptive management involving more permanent barriers or more active enforcement may be required.

Seasonal waterfowl area closures have historically been relatively successful in limiting human entry and disturbance of nesting waterfowl and other species.

Cost Estimate:

Cost estimate for implementation of the Resource Action to limit ORV entry and damage is estimated at $10,000 to $20,000 per year during the first 5 years. If the Resource Action does not substantially reduce ORV damage during the first 5 years of implementation costs could be substantially higher.

Implementation of the waterfowl seasonal area closure would cost about $5,000 to $10,000 per year for signage and enforcement.

Recommendations:

Within the federal Section 7 ESA consultation process, USF&WS has identified these conservation measures to limit ORV damage to vernal pools. Federal ESA compliance requires implementation of these measures.

The existing seasonal closure of waterfowl nesting areas has served to limit waterfowl nesting disturbance and abandonment within this portion of the OWA. Wildlife management is the primary land use within the OWA balanced with appropriate recreational use and development. DWR recommends the continuation of seasonal recreational closures in support of the primary designated use of these lands.

Literature Cited:

DWR, 2004a. Final Report SP-T1: Effects of Project Operations and Features on Wildlife and Wildlife Habitat.

DWR, 2004b. Final Report SP-T2:Project Effects on Special Status Wildlife Species

Resource Action: EWG-78B	**Task Force Recommendation Category:** 2

Habitat Protection Measure-Develop Operational/Management Protocols to Minimize Potential Impacts to Nesting Bank Swallows Related to Project Releases

Date of Field Evaluation: February 2002 through March 2004

Field Evaluation Team: Dave Bogener

Description of Potential Resource Action:

Bank swallow is a State listed Threatened species. The current DWR operational pattern is to release about 2,000 cubic feet per second (cfs) from the Oroville Project during April, May and June. On July 1, releases increase, ramping up to approximately 9,000 cfs. This increased release raises the river stage to an elevation equal to or exceeding the elevation of the lowest burrow in some bank swallow colonies. Most bank swallows fledge by July 1. However, data analyses indicate that at some colony locations, during some years, not all swallows fledge until July 15.

Stage/discharge modeling conducted under Relicensing Study Plan SP-T2 indicates that the current July operational release pattern has the potential to inundate bank swallow burrows while pre-fledged young are potentially present in the burrows (DWR 2004). The current loss of bank swallow production (if any) is unquantified.

DWR initiated informal consultation with DFG under the State Endangered Species Act based on these stage/discharge modeling results. DWR prepared a Biological Assessment under the Joint State/Federal Operations Criteria and Plan (OCAP) environmental review process. The OCAP process was selected opposed to the FERC Relicensing process for several reasons including;

- Earlier implementation date (June 2004 compared with January 2007)
- Potential operational solutions could require coordination with the Federal water project
- DFG suggestion/agreement

Initial informal consultation between DFG and DWR reached several conclusions including;

- Bank swallow losses (if any) are likely to vary from year to year and colony to colony
- Current operational release patterns may result in minor (but unquantified) level of take on an annual basis.

- Short-term spring pulse flows designed to force bank swallows to nest higher on the eroding cutbanks are unlikely to be effective as swallows are known to excavate burrows in moist soils.
- Installation and maintenance of netting or other barriers to bank swallow burrow construction on the lower portion of cutbanks is unlikely to be successful in a dynamic river system.
- Alteration of current July project releases to minimize impacts on nesting bank swallows would have substantial impacts to water supply deliveries and the maintenance of Delta water quality.
- The greatest long-term risk to bank swallow populations on the Feather River in habitat loss related to bank protection.

During informal consultation DFG recommended a mitigation strategy designed to maintain bank swallow populations on the Feather River. This action included;

- DWR purchase conservation easements on lands containing actively eroding bank swallow habitat to provide long-term habitat protection.
- Annual June bank swallow survey of the Feather River to provide long-term population data. These data would be used by DFG to evaluate the effectiveness of the habitat protection/acquisition conservation strategy.

Nexus to Project:

Project releases for water supply, and flood management occur throughout the year. July releases are primarily for water supply purposes, including maintenance of Delta water quality standards.

Potential Environmental Benefits:

Long-term maintenance of bank swallow habitat and production on the Feather River would aid in the species recovery. Further, protection of actively eroding sites along the Feather River from bank protection activities serves to allow natural geomorphic processes to continue with potential benefits to a wide range of aquatic and terrestrial species including salmon, steelhead, VELB, and western yellow-billed cuckoo.

Existing Conditions in the Proposed Resource Action Implementation Area:

DWR (in consultation and coordination with DFG) is currently investigating conservation easements or purchase of actively eroding parcels of private lands containing existing bank swallow colonies on the Feather River below the Project Boundary. Parcels under consideration are projected to continue to actively erode over the next 20 to 30 years and to provide suitable soil characteristics for bank swallow excavation and nesting.

Design Considerations and Evaluation:

Important design considerations are primarily related to site selection and include;

- Site of existing bank swallow colony location(s)
- Site projected to continue to erode over the next 20 to 30 years
- Site with suitable substrate for borrow and nest construction over the next 20 to 30 years
- Site where erosion can be allowed long-term without the need to protect infrastructure (highways, buildings, water conveyance systems)
- Site on the Feather River
- Site where erosion is likely to continue to produce tall vertical banks
- Site capable of meeting future CALFED ERP goals

Land acquisition and conservation easement have proven, with careful site selection, to be effective long-term habitat protection mechanisms. The effectiveness of this mitigation would be evaluated based on several criteria. These criteria are;

- Ability of the site to support nesting bank swallows over time
- Maintenance of bank swallow populations on the Feather River over time.

Synergism and Conflicts:

This OCAP mitigation measure is not directly related to any other currently developed Relicensing Resource Action. However, if Relicensing Study Plan T3/5 indicates that project operations are resulting in reduced recruitment or retention of riparian habitat this same land acquisition could be used to meet riparian mitigation requirements without modifying project operations. Further, opportunities exist to combine riparian planting on an actively eroding site as an alternative to the large woody debris (LWD) placement Resource Action. This alternative to the LWD Resource Action is acceptable in concept to the USF&WS and would avoid the liability issues associated placing LWD within the stream channel. Additionally, lands acquired along the Feather River could be converted to serve as VELB mitigation areas.

Riparian enhancement along the Feather River is an important CALFED ERP goal and may offer opportunities for a larger enhancement area and funding partnerships.

Uncertainties:

As OCAP consultation on this issue is ongoing, it is currently unclear how much bank swallow habitat protection DFG estimates would be required for full mitigation.

Cost Estimate:

Cost estimates provided by Nature Conservancy and River Partners indicate that acquisition of riverfront orchard lands vary between $5,000 per acre and $8,000 per acre. Conservation easement can be significantly less expensive than acquisition depending on the conditions in the easement. For example, conservation easements structured to allow the farmer to continue farming at his own risk while allowing bank erosion are occasionally negotiated at about one-half the purchase price.

Adequate land area to cover potential erosion over the next 20 to 30 years for two actively eroding bank swallow colony locations could equal 100 acres at some Feather River locations. Land acquisition costs related to this OCAP mitigation measure based on acquisition of 100 acres, are estimated in the range of $500,000 to $800,000. It may be possible to acquire a conservation easement for the same area at approximately one-half of these costs.

Recommendations:

DWR should continue to consult with DFG to design a mitigation strategy for impacts identified under the OCAP BA. DWR should provide regular updates on the OCAP consultation to EWG Relicensing stakeholders. DWR should carefully evaluate opportunities associated with any land acquisition or easement for potential Relicensing or CALFED ERP benefits.

Resource Action: EWG-79	**Task Force Recommendation Category:** 2

Improve Wildlife Habitat within the Oroville Wildlife Area for Wetland and Riparian Dependent Wildlife Species

Date of Field Evaluation: February 2002 through March 2004

Field Evaluation Team: Dave Bogener

Description of Potential Resource Action:

This Resource Action evaluates opportunities to enhance wildlife habitats within the Oroville Wildlife Area (OWA) for wildlife species dependent upon wetland and riparian habitats through reclamation of barren dredger tailings.

Within the OWA about 615 acres of barren dredger tailings are present (DWR 2004a)). These barren habitats provide habitat for relatively few wildlife species and are barriers to dispersal of some wildlife species (DWR 2004a). California Wildlife Habitat Relationship (CWHR) modeling indicates that barren habitats within Butte County can provide habitat for a maximum of 82 species (DWR 2004a). Barren habitat is not essential for any wildlife species occurring in Butte County. Further, most CWHR species predictions for Butte County barren habitats are shorebirds which forage in exposed barren mudflats rather than gravel piles.

CWHR modeling indicates that freshwater emergent wetland habitats can support between 146 and 163 vertebrate wildlife species depending on the size or density of seral stages present. Valley/foothill riparian habitat can support between 218 and 255 vertebrate wildlife species depending on the size or density of seral stages present.

Conversion of barren gravel piles to a combination of freshwater emergent wetland and riparian habitat will greatly increase wildlife diversity on currently barren habitats, enhance opportunities for wildlife movement and dispersal, and improve recreational access.

The primary tool for implementation of this Resource Action is carefully directed commercial gravel harvest. Even utilizing commercial gravel harvest as a site restoration tool only small acreages of habitat restoration will be realized on an annual basis due to the vast quantities of materials to be removed at some locations

Nexus to Project:

This Resource Action does not have a direct nexus to Relicensing. However, the proposed Resource Action could be implemented in coordination with other Relicensing related Resource Actions including:

- Side channel creation for salmonid habitat improvement
- Gravel infusion for salmonid spawning habitat restoration

Potential Environmental Benefits:

The principal environmental benefits of this Resource Action are greatly increase wildlife diversity on currently barren habitats and opportunities for removal of barriers to wildlife movement and dispersal. The potential exists to create additional habitat, increase habitat block size, or improve habitat connectivity for western yellow-billed cuckoo, a State listed Endangered species and a Federal candidate for listing. Creation of additional emergent wetland habitat areas would provide additional habitat or improve habitat connectivity for the State and Federally listed giant garter snake. Further, any creation of additional giant garter snake habitat could be used as mitigation in advance for project related habitat losses "take" in other areas within the project.

Existing commercial gravel harvest within the OWA predates reclamation planning requirements (Ward Tabor, DWR pers. comm..). Some post-harvest site conditions resulting from commercial harvest have generally been less than optimal from a wildlife management standpoint. This Resource Action would require that future post-harvest site conditions are optimal for natural revegetation and rapid conversion to productive wildlife habitats. Further, the contracts for future gravel harvest could be written in a manner which provides economic incentives to commercial gravel operators to modify past extraction areas to a more acceptable condition.

Potential Constraints:

This Resource Action was initially suggested by the California Department of Fish and Game (DFG), the land managers of the OWA. DWR retains the mineral rights within the OWA and implementation of this Resource Action cannot occur without coordination and cooperation between DFG and DWR.

The principal constraints to this Resource Action are impacts to Cultural Resources. The dredger tailings within the OWA are all that remain of the once extensive mining area. These tailing areas are considered a "Historic Mining District" potentially suitable for designation and protection under both State and Federal law. Prior to disturbance of these potentially significant historical resources an evaluation of significance relative to the State or Federal National Historic Preservation acts must occur.

Impacts to recreational uses are considered generally beneficial as the relatively steep unstable gravel tailings are not conducive to human access or recreational use.

Gravel resources have value. Sale of gravel resources could provide revenues to the State of California and provide the Butte County area with an economical local source of material for future development.

Existing Conditions in the Proposed Resource Action Implementation Area:

Within the OWA about 615 acres of barren dredger tailings are present (Figure 5.4.1). These barren habitats provide habitat for relatively few wildlife species and are barriers to dispersal of some wildlife species. California Wildlife Habitat Relationship (CWHR) modeling indicates that barren habitats within Butte County can provide habitat for a maximum of 82 species (DWR 2003) Barren habitat is not essential for any wildlife species occurring in Butte County. Further, most CWHR species predictions for Butte County barren habitats are shorebirds which forage in exposed barren mudflats rather than gravel piles.

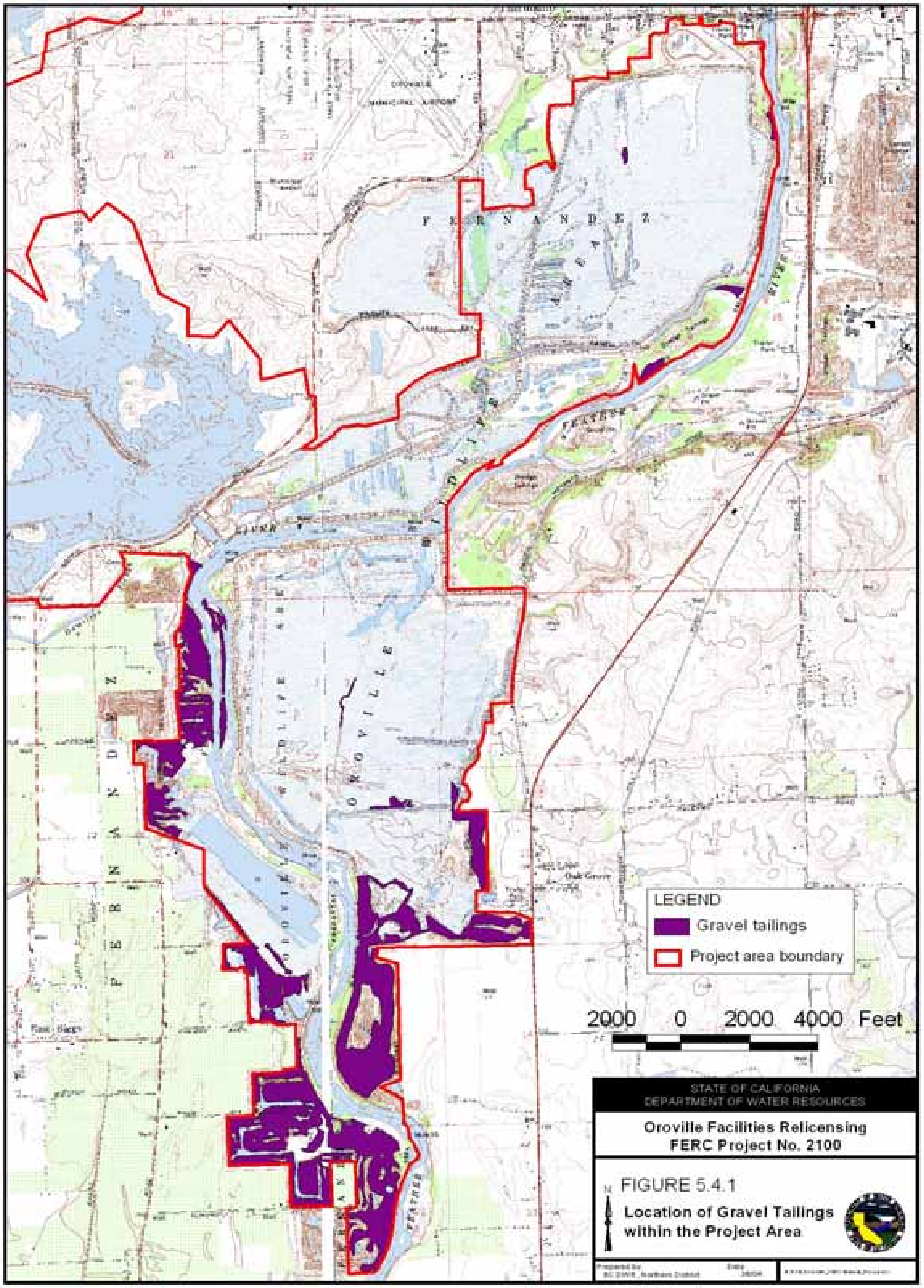
CWHR modeling indicates that freshwater emergent wetland habitats can support between 146 and 163 vertebrate wildlife species depending on the size or density classes present. Valley/foothill riparian habitat can support between 218 and 255 vertebrate wildlife species depending on the size or density classes present.

Conversion of barren gravel piles to a combination of freshwater emergent wetland and riparian habitat will greatly increase wildlife diversity on currently barren habitats, enhance opportunities for wildlife movement and dispersal, and improve recreational access.

Only commercial gravel mining interests have the ability to remove and dispose of the massive quantities of material stored within the OWA. To result in the desired future wetland or riparian condition, gravel removal would have to be carefully designed, monitored, and implemented.

Design Considerations and Evaluation:

Gravel removal would be designed to optimize natural vegetative recolonization.
The key design considerations for successful implementation of this Resource Action are depth of gravel removal (relative to the groundwater table) and percentage of fine material remaining following gravel removal. Development of riparian habitat would require removal of overburden to a level about 1.5 to 3 feet above the July ground water elevation at each site. Ground water levels in the OWA closely correspond with river stage (DWR 2004b). Development of freshwater emergent wetland habitat would require excavation to 3 to 4 feet below the July ground water elevation at each site. These depths would optimize natural recolonization of aquatic and emergent wetland plant species.


LEGEND
Gravel tailings
Project area boundary
2000 0 2000 4000 Feet
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
Oroville Facilities Relicensing
FERC Project No. 2100
FIGURE 5.4.1
Location of Gravel Tailings within the Project Area

Retention of fine materials, (clay, silt and sand) is essential for rapid natural recolonization. Dredger operations normally produce conditions where larger cobble material is located on the top of the dredger pile with fine materials are located near the bottom. Gravel harvest contract specifications could be developed requiring retention of or capping the sites with fines to insure rapid vegetative establishment.

A reclamation plan for each site would be developed by DWR, in coordination with DFG, which identifies in detail the post gravel harvest condition relative to the depth and size of required fine material as well as excavation depths. Implementation of the reclamation plan would be included as part of the gravel harvest agreement/contract. Monitoring will be required to minimize overexcavation. Steep sided lacustrine habitat is not the desired future condition.

Materials harvest for initial project construction removed enormous quantities of materials from selected areas within the OWA. These large areas rapidly revegetated and are currently dominated by even aged cottonwood stands with highly variable amounts of shrub (willow) understory). This historic information indicates that conversion of barren gravel areas to riparian habitat can occur over large areas through natural revegetation processes.

Synergism and Conflicts:

This Resource Action could be designed in coordination with Resource Actions EWG 16B and/or EWG 92. Creation of additional side channel juvenile fish rearing habitat could require excavation of dredger tailings depending on channel location selected. EWG 92 involves placement of an average annual quantity of 10,000 cubic yards of gravel within the low flow reach of the Feather River for fish spawning substrate habitat restoration. The existing 615 acres of State owned dredger tailings could be used as a local, cost effective source for this material.

Uncertainties:

After 50 + years most dredger tailings remain unvegetated. Distance to ground water and lack of fine soils in the dredger tailings are likely to result in maintenance of this unvegetated condition over the next 50 years. Interpretation of historic air photos indicates that carefully designed and implemented gravel removal can rapidly result in the establishment of riparian and wetland habitats within the OWA. If the gravel harvest/removal is conducted based on site specific reclamation plans there is a high likelihood of success.

The principal uncertainties related to impacts to historic resources and the willingness of and ability of commercial gravel mining interests to meet the reclamation design criteria.

Cost Estimate:

The principal costs associated with the proposed Resource Action involve those associated with development of detailed site specific reclamation plans, contract preparation, and monitoring of gravel removal.

Monitoring of historic gravel mining within the OWA indicate that due to the vast quantities of materials present in some locations it can take 5 to 10 years of commercial harvest to remove the required material at each reclamation site. Therefore, a reclamation plan and contract for an individual site would be required at 5 to 10 year intervals. Monitoring would be required on an annual basis initially. More frequent monitoring would be required as gravel harvest approaches final design criteria.

Estimated costs for development of an individual reclamation plan and associated contract/agreement are $50,000 every 5 to 10 years. Annual monitoring costs should not exceed an average of $5,000 per year. It may be possible to offset these costs through gravel lease fees.

Recommendations:

Use of commercial gravel harvest as a site reclamation/restoration tool to convert barren habitats to more productive and diverse wildlife habitats is likely the only viable long-term restoration option within the OWA due to the vast quantities of materials present.

This form of restoration offers potential benefits to wildlife species diversity, and to species protected under the State or Federal Endangered Species acts. Potential benefits to economic development in the project vicinity and improved recreational access may also occur.

It is currently unknown which, if any, of the dredger tailings could be harvested in compliance with State or Federal Historic Resource regulations. Further, it is currently unknown if commercial gravel operators have any need for additional supply or interest in cooperating with DWR or DFG to implement this Resource Action.

Literature Cited:

DWR 2003. Relicensing Study T4 Final Report
DWR 2004a. Relicensing Study T-1 Final Report
DWR 2004b. Relicensing Study W7 Final Report
Ward Tabor, DWR Legal, 2003. Personnel communication

Resource Action: EWG-87	**Task Force Recommendation Category**: **2**

Modify and/or Operate the Oroville Facilities to Provide Additional Warm Water for Agriculture and Recreational Activities, and Additional Cold Water to Satisfy Salmonid Habitat Requirements.

Description of Potential Resource Action Measure:
This measure would seek to alter the distribution of water temperatures in the Thermalito Afterbay to benefit both salmonids in the lower Feather River downstream of the Thermalito Afterbay outlet and rice farmers that obtain their irrigation water from the Afterbay. The salmonids would benefit from releases of colder water from the Afterbay, while the farmers would benefit from warmer irrigation water, particularly during spring, when the rice germinates. Currently, relatively cold water from the Thermalito Pumping-Generating Plant tail channel discharges into the small northeastern arm of the Thermalito Afterbay (Figure 1). The point of discharge is in the same part of the Afterbay as the outlets to the Western and Richvale Canals, while it is located at the opposite end of the Afterbay from the outlet to the Feather River. During warm weather, water heats up as it moves across the Afterbay and, therefore, the water released to the river is several degrees warmer than that entering the canals, and also warmer than the water already in the river (the Low Flow Channel).

This Resource Measure proposes a variety of structural changes and additions and/or operational changes to effect changes in the distribution of water temperatures in the Afterbay. The structural changes and additions are designed to reduce warming of the water destined to be released to the Feather River at the Afterbay river outlet, while at the same time increasing warming of the water destined to enter the Western and Richvale Canals and other irrigation canals. The structural features would cause the cold water entering the Afterbay to more quickly reach the river outlet and would cause the water used for irrigation to reside longer in the Afterbay before entering the irrigation canals. The result of these changes would be colder water for salmonids in the river and warmer water for the rice farmers. Table 1 provides a list of specific potential actions, including both structural and operational modifications, for improving water temperature distributions in the Afterbay. This list was developed during discussions of the Engineering and Operations Workgroup. The table also notes potential environmental and power effects of each action. The actions are categorized into the following five basic groups, according to their means of effecting temperatures changes:

- Methods to convey cold water to the Afterbay outlet.
- Methods to convey warmer water to the Afterbay agricultural diversion points.
- Methods to increase the residence time of water in the Afterbay.
- Methods to warm the water that has already entered the diversion canals or has already been diverted to individual farms.
- Methods to change the input temperature of water entering the Afterbay.

Table 1. Options for Thermalito Afterbay Temperature Improvements

	Changes to the Oroville Facilities		Effects	
	Operational	Structural	Environmental	Power
A. Convey Cold Water to Thermalito Afterbay Outlet				
Increase flow in LFC from May 1 through June 30	X			X /e/
Construct canal outside of TAB to FR	X	X	X /a/	X /e/
Install a suite of buried pipes in TAB		X	X /b/	
Use baffles to re-direct return flow from canal	X	X	X /b/	
Dredge underwater conveyance channel from Thalweg of TAB (requires facilities to “lift” into outlet)	X	X	X /b/	
Install temperature curtain (to cool water) on the west side of Thermalito Afterbay		X		
Construct canal outside of Thermalito Afterbay to transport water into the Afterbay at another location (presumably southeastern)		X		
B. Convey Warm Water to Agricultural Diversion Canals				
Use baffles to re-direct return flow from conveyance structures	X	X	X /b/	
Draw warmer water for agricultural diversions	X		X /b/	
Install baffles to warm water in Thermalito Afterbay		X		
Install sheet piles to warm water on west side of Thermalito Afterbay		X		
Relocate Sutter Butte Canal Outlet		X		
Relocate Richvale Canal Outlet and Western Canal Outlet		X		
C. Increase Water Residence Time in Thermalito Afterbay				
Smooth agricultural peak demand to allow longer residence time	X			
Manage TAB for agricultural flows (maximize residence time, TAB levels, need baffles)	X	X	X	X /e/
Re-configure island in TAB to redirect water flow and increase residence time	X	X	X	
Connect land islands to partition Thermalito Afterbay		X		
D. Increase Water Temperature After Delivery to Agricultural Diversion Canals				
Install power generation units (no head) at agricultural canal outlets to increase temperature	X	X	X	X /c/
Solar panels on canals with strip heaters in water	X	X	X	X /c/
Stand pipe hot air bubbles at agricultural canal outlets	X	X	X	X /c/
Pump warm air into water to increase water temperature	X	X	X	X /c/
Construct and operate a co-generation plant on Western Canal that uses rice straw waste to increase water temperature	X	X	X	X /c/
Warm Western Canal water by building warming ponds in canals		X /g/		
Place pool solar blankets on TAB	X	X	X	
Develop “shallow” pond to warm water				
Develop warming checks at turnouts – land retirement and purchase for ponding				
E. Change Thermalito Afterbay Inflow Temperature				
Operate Thermalito Afterbay to warmer temperatures from May 1 through June 30	X	X	X	X
Install chillers to cool FRFH water from May 1 through Jun 30	X	X		X /f/
Alternative source of cold water for FRFH (well water or withdraw water from deeper Lake elevations), i.e., Palermo Canal	X	X	X	

/a/ Some impacts to vernal pools would be expected. Such footprint effects could be minimized and mitigated.
/b/ Would result in habitat effects during construction only.
/c/ Effects peaking operations only.
/d/ Effects pump-back operations.
/e/ Effects peaking and pump-back operations.
/f/ Would require electric service
/g/ Ponds would be located outside

The structural changes discussed by the E&O Workgroup to provide colder water at the Afterbay river outlet all involved measures to hasten the movement of the cold Afterbay inflow to the river outlet and to retard the movement of water from the inflow to the irrigation canal outlets. One action would construct a canal to transport cold water directly from the Thermalito Pumping-Generating Plant tail channel to the southeastern portion of the Afterbay, near the river outlet. A related action would install a series of dams or flow barriers to isolate the three principal embayments of the eastern Afterbay from the main body of the Afterbay and would connect these embayments with canals (Figure 1). Both of these actions would speed movement of the cold inflow water to the river outlet and would retard movement of the water destined for the Western, Richvale and Lateral Canals, leading to greater warming. Note, however, that without mitigating actions, the Sutter Canal, which is located close to the river outlet (Figure 1), would likely have colder water than it currently has.

Structural changes to warm the water in the Afterbay include constructing a curtain of sheet pile to isolate the irrigation canal outlets from the main body of the Afterbay (Figure 1). This curtain would increase the distance required for water to travel from the point of inflow to the canals, thus increasing its residence time and amount of warming. This action would be particularly effective if combined with the installation of barriers to contain the cold water inflows in the eastern portion of the Afterbay, as discussed in the previous paragraph and shown in Figure 1. Other structural changes to warm the water for rice farmers include installing various types of heating devices in the irrigation canals.

Several operational changes to warm the Afterbay water were discussed by the E&O Workgroup. One action involved reducing the amplitude of the peak irrigation withdrawals in the spring rice germination period by scheduling each canal to divert at a different time. When the diversions at all canals peak simultaneously, the storage volume of the Afterbay is rapidly exhausted and the water subsequently entering the Afterbay moves quickly from the inflow to the irrigations canals with minimal warming. By moderating the irrigation withdrawals, residence time in the Afterbay is increased and the water entering the irrigation canals would likely remain relatively warm throughout the rice germination period. Another change in operations that was earlier believed to warm Afterbay water temperatures is to increase pump-back operations. However, results of recent water temperature modeling provide little evidence that pump-back operations result in warming of water in the reservoir or in the Thermalito Complex (C. Creel, personal communication).

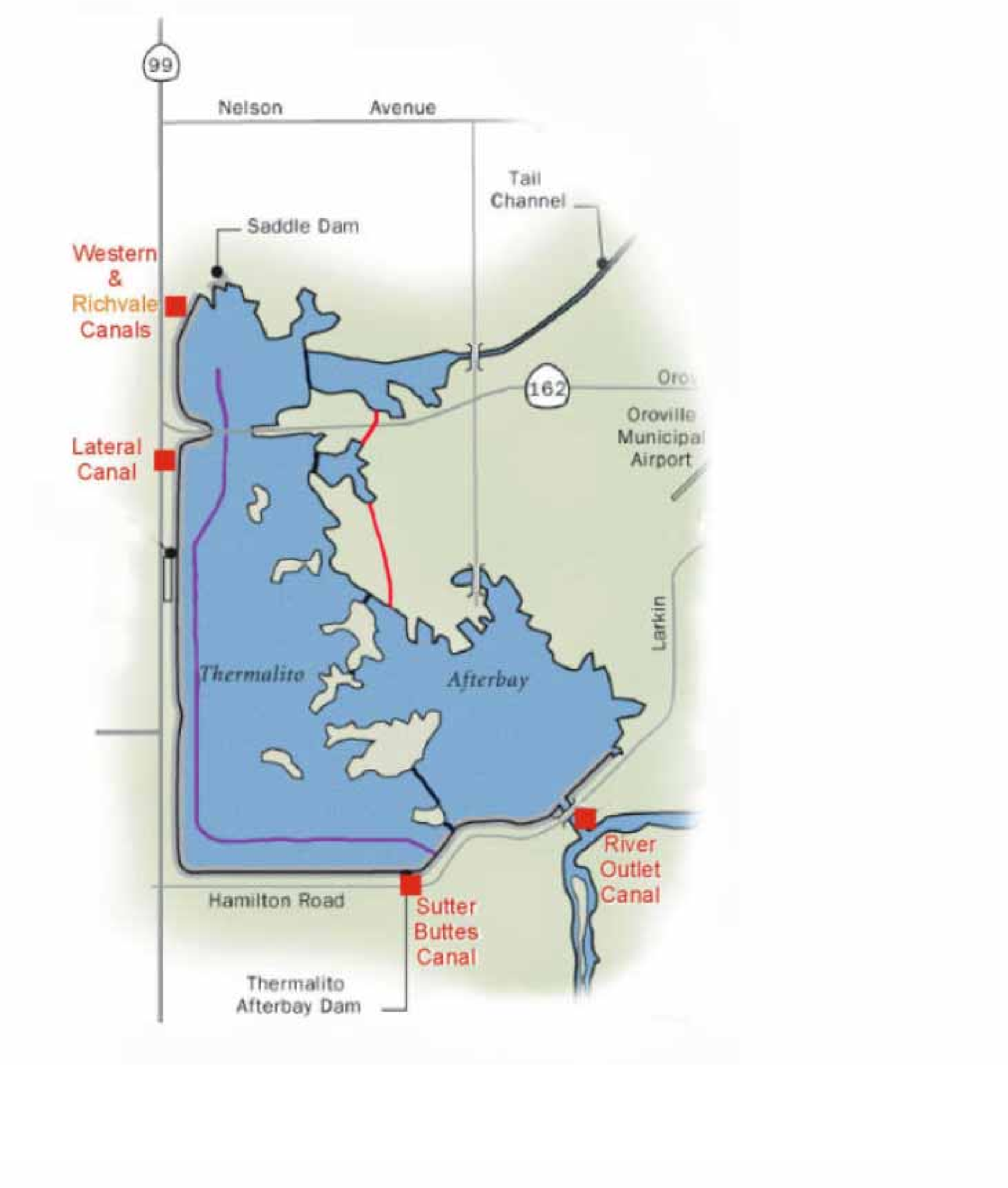


Figure 1. Example of the Thermalito Afterbay with Two Open Channel Conveyance Facilities, Temperature Curtain, and Dams

Date of Field Evaluation: No field evaluation was conducted

Evaluation Team: Phil Unger and Anita Thompson

Related Resource Actions:

- EWG-28, that proposes to manage water levels in the Thermalito Afterbay to provide increased nesting and initial rearing habitat for nesting warmwater species.
- EWG-34A & 34B, which propose to reduce rates of fish predation on juvenile salmonids by reducing water temperatures.
- EWG-35A and EWG-35B, that propose to reduce water temperatures at the Thermalito Afterbay Outlet and in specific areas of the Feather River to reduce the feeding rates of predators on rearing and emigrating juvenile salmonids in the Feather River.
- EWG-36, which proposes to operate the Oroville Facilities in a manner that would provide colder water in the low flow channel of the Feather River for benefit of Chinook salmon and steelhead.
- EWG-37, which proposes to operate the Oroville Facilities in a manner that would provide colder water in Feather River downstream of the Thermalito Afterbay river outlet for benefit of Chinook salmon and steelhead.

- EWG-102, which proposes to provide water temperatures in the lower Feather River that mimic historic (pre Oroville Dam) conditions to help maintain the genetic integrity of the spring-run Chinook salmon.

Nexus to the Project:

Water temperatures in much of the lower Feather River are strongly affected by operations of the Oroville Facilities. The Oroville Facilities allow project operators to regulate the depth in Oroville Reservoir from which water is released, the amount of water released from the reservoir into the river, the amount of water diverted from the LFC of the river through the Thermalito Complex, and the amount of water pumped back into the reservoir from the Thermalito Complex. These operational controls give the operators various degrees of control over water temperatures in the LFC and the upper reaches of the HFC.

The Thermalito Afterbay has important water temperature effects. The Afterbay is large and shallow and, therefore, substantial warming occurs in the Afterbay during warm weather. The warming of water in the Afterbay generally benefits agricultural and recreational users and improves habitat conditions for warm water species in the Afterbay and in the Feather River downstream of the Afterbay outlet. However, the release of warm water from the Afterbay to the river adversely affects coldwater fish species, particularly salmonids. A recent evaluation conducted by the EWG fisheries technical team of Chinook salmon and steelhead water temperature needs in the Feather River suggests that under current Oroville Project operations, the water temperatures in the HFC of the Feather River are seasonally too warm for salmon and steelhead holding, spawning and rearing. Releases of water into the Feather River from the Thermalito Afterbay contribute substantially to the elevated water temperatures of the HFC.

The 1983 agreement between the California Department of Water Resources (DWR) and California Department of Fish and Game (DFG), Concerning the Operation of the Oroville Division of the State Water Project for Management of Fish and Game, established quantitative water temperature criteria for the lower Feather River. In this agreement, the Oroville Project is required to meet quantitative water temperature criteria at two downstream locations: the Feather River Hatchery (FRH) and the LFC at Robinson's Riffle (River Mile 61.6).

The water temperature criteria at the FRH and Robinson's Riffle are the principal water temperature targets controlling Oroville Project operations, but other water temperature objectives and goals occasionally influence project operations and potentially affect water temperatures in the HFC. The 1983 agreement established a narrative water temperature objective for the Feather River downstream of the Thermalito Afterbay river outlet. This objective requires water temperatures downstream of the Thermalito Afterbay outlet that are suitable for fall-run Chinook salmon during the fall (after September 15) and suitable for shad, striped bass and other warmwater species from May through August. This narrative has no direct effect on operations because it is not well defined, but it has encouraged operators to seek opportunities to provide colder water to the HFC during the fall months.

An informal water temperature goal of the Oroville Facilities operators exists for the Thermalito Afterbay. This goal recognizes the need of local rice farmers for warm water temperatures during spring and summer for germination and growth of rice. Most of the rice farmers divert their irrigation water from the Thermalito Afterbay. Water temperature goals to support rice production are a minimum of 65°F during April through mid-May and a minimum of 59°F for the remainder of the growing season. Although DWR is not obligated to meet these goals, Project operators try to accommodate the rice farmers by releasing water as close as possible to the maximum temperature allowed under the FRH criteria. Because most of the water in the Thermalito Afterbay ultimately spills into the HFC of the Feather River, increases in Thermalito Afterbay water temperatures likely produce higher HFC water temperatures.

Potential Environmental Benefits:
This Resource Action would result in release of cooler water from the Thermalito Afterbay outlet to the lower Feather River, which would improve water temperatures for Chinook salmon and steelhead in the HFC. The action would provide the greatest benefit to salmon and steelhead during April through October. This period includes the

rearing period for spring-run Chinook salmon and steelhead and the immigration, holding and spawning period for spring-run Chinook salmon.

The EWG fisheries team determined Chinook salmon and steelhead water temperature needs for each life-stage by synthesizing information obtained from the fisheries literature. Both fall-run and spring-run Chinook salmon spawn in the LFC beginning in early September. The upper reaches of the HFC have an abundance of suitable spawning gravels, but limited spawning occurs in the HFC because water temperatures are generally too warm.

The EWG team determined that spawning and egg incubation water temperature requirements for Chinook salmon are no more than 56°F or 58°F (the two values reflect minor differences in the set of literature sources used for deriving the critical temperature estimates). Based on benchmark study water temperature modeling runs of existing (2001) conditions, the September median daily average water temperatures in the HFC ranged from about 62 °F downstream of the Afterbay outlet to about 67°F upstream of Honcut Creek, and the 95th percentile of daily maximum water temperatures ranged from about 67°F to 74°F (Figure 2). These results indicate that a substantial reduction in water temperatures in September would be required to provide suitable spawning conditions for the Chinook salmon in the HFC. The analysis of water temperatures is limited to the HFC upstream of Honcut Creek because this portion of the HFC has the best spawning habitat conditions and because, realistically, modifications to the Oroville Facilities or their operations would be unable to affect water temperature further downstream.

Steelhead begin spawning about December, but continue spawning until about April, and egg incubation may continue through May. The EWG fisheries technical team determined that spawning and egg incubation temperature requirements for steelhead are 52°F and 54°F (again, the two values reflect differences in the set of literature sources used for estimates). Based on the existing conditions benchmark study modeling results, the median daily average and the 95th percentile of daily maximum water temperatures in the HFC were consistently higher than the steelhead spawning and egg incubation temperature requirements (Figure 2). Substantial reductions in water temperatures would be required to provide suitable conditions for steelhead egg incubation.

Providing cooler water temperatures in the HFC during the summer months could benefit spring-run and fall-run Chinook salmon. Spring-run adults hold in pools in the lower Feather River from late spring through summer. Fall-run migrate upstream in late summer and hold more briefly. The EWG fisheries technical team determined that upstream migration and holding temperature requirements for adult spring-run and fall-run Chinook salmon are 60°F and 64°F (the two values reflect differences in the set of literature sources used for estimates). During the summer months (June through September), the median daily average and 95th percentile of maximum water temperatures at both locations in the HFC were generally higher than these temperature requirements (Figures 2). Therefore, reducing water temperatures from June through September would likely benefit migrating and holding Chinook salmon, particularly spring-run Chinook salmon, by providing additional holding habitat in the upstream section of the HFC.

In addition to improving holding, spawning and rearing conditions for salmon and steelhead, releasing colder water from the Thermalito Afterbay may also enhance juvenile salmonid survival by reducing predation from warmwater fish species. Providing warmer water to the irrigation canals in the Afterbay provides clear benefits to farmers, particularly rice farmers. As discussed previously, the spring period of rice germination is the most important for warm water deliveries. Warm water in the Afterbay would also benefit the existing warmwater fisheries as well as swimming and other contact recreational activities. However, this Resource Action would likely not increase water temperatures throughout the Afterbay, so the benefit to warmwater fish species and recreation would depend on the distribution of the fish and locations of recreational facilities.

Potential Constraints:
This Resource Action could be constrained by regulatory requirements. The narrative objective for water temperatures in the HFC below the Thermalito Afterbay river outlet requires water temperatures that are suitable for shad, striped bass and other warmwater species from May through August. Releasing colder water from the Afterbay to the HFC during the spring and summer could make it difficult to meet this objective.

Measures to reduce water temperatures of the releases from the Afterbay are also potentially constrained by the goal to provide suitable warm water for recreational activities in the HFC and needs of irrigators that divert water from the HFC.

A major constraint of some of the measures proposed for this Resource Action is a loss of generation resulting from the elimination of pump-back operations. For example, the second item listed in Table 1 would bypass the Afterbay entirely, thus eliminating the capability of pump-back operations.

Structural changes in the Afterbay may have recreational as well as environmental effects that would have to be considered. For instance, installation of barriers and curtains would greatly constrain boating opportunities in the Afterbay. The reduction of water temperatures along the eastern margin of the Afterbay would reduce enjoyment of existing swimming areas. In addition, construction associated with some of the proposed structural changes would potentially affect vernal pools east of the Afterbay. Other potential environmental and power generation effects of this Resource Action are listed in Table 1.

Existing Conditions in the Proposed Resource Action Implementation Area:
The Thermalito Afterbay is situated downstream of the Thermalito Forebay, which is located downstream of the Thermalito Diversion Pool and Oroville Reservoir. Water from the Afterbay is released through the Thermalito Afterbay outlet into the Feather River downstream of the Low Flow Channel. Some Afterbay water is also diverted into irrigation canals. The Afterbay provides storage for the pump-back operation to Lake Oroville. The facility also provides recreational opportunities and provides agricultural water for several local irrigation districts. The water surface area of the facility at maximum operating storage is 4,300 acres.

The Thermalito Afterbay has a diverse water temperature regime. During the warmer times of year, the temperature of water released from the Afterbay to the Feather River is warmer than that already in the river because the water diverted through the Thermalito Complex has a longer residence time, including time in shallow reservoirs, than the water in the LFC. The Afterbay is much the largest reservoir in the Thermalito Complex and accounts for most of the warming. The combination of cold inflowing water and large areas of shallow water results in a wide range of water temperatures within the Thermalito Afterbay. This wide range of temperatures, the adverse effects of warm water releases on the coldwater fisheries of the river, and the benefits of providing warm water to the irrigation canals result in a complicated water temperature management program for the Afterbay.

The upstream section of the HFC, extending about 14 miles from the Thermalito Afterbay Outlet to Honcut Creek, is the portion of the Feather River most affected by this Resource Action. The minimum flows and the water temperature targets in the HFC are established by a 1983 agreement between DWR and DFG. The instream flow requirements are 1,700 cfs from October through March and 1,000 cfs from April through September for wetter years (> 55% of normal runoff), and 1,200 cfs for October through February and 1,000 cfs for March through September for drier years. As previously described, the water temperature must be suitable for fall-run Chinook salmon after September 15, and they must be suitable for shad, striped bass, and other warmwater species, from May through August.

Spring and summer water temperatures in the HFC are typically quite a bit warmer than those in the LFC in large part because of the large volumes of relatively warm water released to the HFC from the Thermalito Afterbay outlet. As previously described, water temperatures in the Afterbay are relatively high because of the Afterbay is large and shallow and has a long residence time. The contribution of the Afterbay outlet releases to the total flow of the HFC is typically greater than that of the LFC flow.

The release of large flows with relatively high water temperatures from the Thermalito Afterbay outlet typically results in a sharp thermal gradient from the downstream end of the LFC to the upstream end of the HFC. Based on results of water temperature monitoring conducted in 2002 and 2003, water temperatures in the HFC just downstream of the Afterbay outlet are often several degrees warmer (as much as 8^oF in early June 2002) than temperatures in the lower part of the LFC (upstream of Thermalito Afterbay Outlet), particularly in the late spring and early summer (Figure 3). This change in water temperature may be stressful for migrating fishes, but also elevates predation risk because of the increased abundance of piscivorous bass and Sacramento pikeminnow.

Design Considerations and Evaluation:
DWR's Division of Engineering (DOE) is performing an initial estimate of cost for several design options that include open channel conveyance facilities and systems of small dams and dikes to convey the cold Afterbay inflow water more directly to the Feather River. The cost information along with the water temperature data that have been collected in the field are the basis for a reconnaissance-level evaluation of the potential changes in water temperatures. Other reconnaissance-level analyses regarding environmental and recreational impacts may be necessary before staff would be able to provide a recommendation to DWR management.

DOE's analyses of construction costs suggest that conveyance facilities range between $14 million and $22 million. Below are brief descriptions of the options that were analyzed.

- Segregate cold water from the rest of the Afterbay. This design option proposes construction of a temperature curtain along the eastern edge of Thermalito Afterbay. The initial cost estimate is approximately $15 million.

- Construct canals to convey some of the water. Two of DOE's design options propose construction of open conveyance channels to re-direct water from the northernmost portion of the Afterbay to a region closer to Afterbay river outlet. One of these design options includes a lined channel and the other includes an unlined channel. The channels would be large enough to convey all of the water that is destined for release to the river about 80% of the time. However, some water would overflow into the northern portion of the Afterbay during peaked operations. Initial cost estimates for these two design options are approximately $14 million and $11 million, respectively.

- Construct canals to convey all of the water. These options are the same as the set above except the canals would be capable of conveying the full capacity of the power plant. The initial cost estimate for these options are $22 million and $18 million, respectively.

Based upon the assumption that it would be desirable to convey cold water more efficiently to the Thermalito Afterbay river outlet, any of the above options could merit further study and analyses. However, an expected drawback of all these options, is that they would likely reduce the temperature of water diverted at Sutter Buttes Canal. Therefore, these options would likely need to be paired with options to convey warmer water to the agricultural diversion points. Figure 1 shows an example how two options could be combined to both reduce the temperature of water released to the river while avoiding significant reductions in water temperatures to agricultural diversions.

The effectiveness of this Resource Action would be evaluated by comparing water temperatures measured at the Thermalito Afterbay outlet, all the Afterbay irrigation canal outlets and several locations in the HFC before and after implementing the action. The comparisons would use water temperature modeling to adjust for differences in atmospheric conditions and other potentially confounding variables in making the comparisons. Water temperature data currently being collected in the Afterbay, the irrigation canals, and the lower Feather River will provide the information on water temperatures before implementing any changes in project operations.

Synergisms and Conflicts:
This Resource Action is compatible with the resource goals described in EWG-36 and EWG-37, which provide additional cold water for Chinook salmon and steelhead. By benefiting coldwater fishes, the Resource Action would likely enhance recreation in the HFC, providing increased summer angling opportunities for trout and Chinook salmon. This Resource Action would likely reduce the steep thermal gradient between the HFC and the LFC and thereby improve upstream passage and habitat conditions for anadromous salmonids, which are resource goals of many of the proposed resource actions. The colder water that would result from this measure might also help reduce predation on juvenile salmonids because the colder water would reduce metabolic rates of the fish predators in the HFC, and thereby potentially reduce their feeding rates. Reduced predation on juvenile salmonids is the resource goal for Resource Actions EWG-35A, EWG-35B and EWG- 27.

Currently the Thermalito Afterbay provides storage for the water required by the pump-back operation to Lake Oroville. As noted earlier, one of the measures proposed for this Resource Action bypass the Afterbay, which would eliminate the possibility of pump-back operations. Other measures would likely also interfere to some degree with pump-back operations.

As previously described, the Resource Action would potentially conflict with fisheries and recreational opportunities in the Afterbay and could have impacts on vernal pools east of the Afterbay. Public safety issues must also be considered and analyzed regarding the installations of structures in the Afterbay.

Uncertainties:
An important uncertainty regarding this Resource Action concerns its effectiveness in controlling spring water temperatures. Based on water temperature data collected in 2002 and 2003 and analyses of the E&O Workgroup, it appears that water temperatures in the Afterbay closely track air temperatures during early spring. As spring air temperatures increase, the residence time of the water in Afterbay becomes increasingly important in determining Afterbay water temperatures. If, as these results

seem to indicate, residence time has little effect on Afterbay water temperatures during spring, then the many measures included in this Resource Action to increase residence time may not have the desired effect of warming water for rice farmers during the spring, and other measures, such as releasing warmer water from Oroville Reservoir, would be required to meet rice farmers' water temperature goals. More generally speaking, there is no guarantee that installation of the proposed structures in and around the Afterbay would result in satisfying the water temperatures needs of all beneficial uses.

Other uncertainties regarding this Resource Action include the following:

- Effect on the fish rearing facility at Thermalito Annex near the Thermalito Afterbay.
- Whether the Resource Action could be implemented without conflicting with DWR agreements or goals, including the FRH water temperature criteria, the agreement to accommodate water temperature needs of rice farmers, and the agreement to provide water temperatures downstream of the Thermalito Afterbay outlet from May through August that are suitable for shad, striped bass and other warmwater species.
- The amount of revenue that would be lost because of changes in power generation.

Although, as previously noted, results of recent water temperature modeling seem to indicate that Thermalito pumpback operations minimally affect water temperatures; more analysis is needed to resolve this matter.

A major challenge for considering this proposed resource action is cost and financing. DWR must consider means by which the construction costs will be financed and repaid. It is likely that financing and repayment of this proposed resource action will be a subject of settlement negotiations.

Cost Estimate:
DOE is currently reviewing the cost of several options for designing the proposed open channel conveyance facilities and system of small dams and dikes.

Recommendations:
DWR, within the E&O Work Group may wish continue to review the costs and potential benefits of several options for designing the proposed open channel conveyance facilities and system of small dams and dikes.

Figure 2. Median of Daily Average, 95th Percentile of Daily Maximum, and 5th Percentile of Daily Minimum Water Temperatures for Benchmark Study Conditions; High Flow Channel Stations

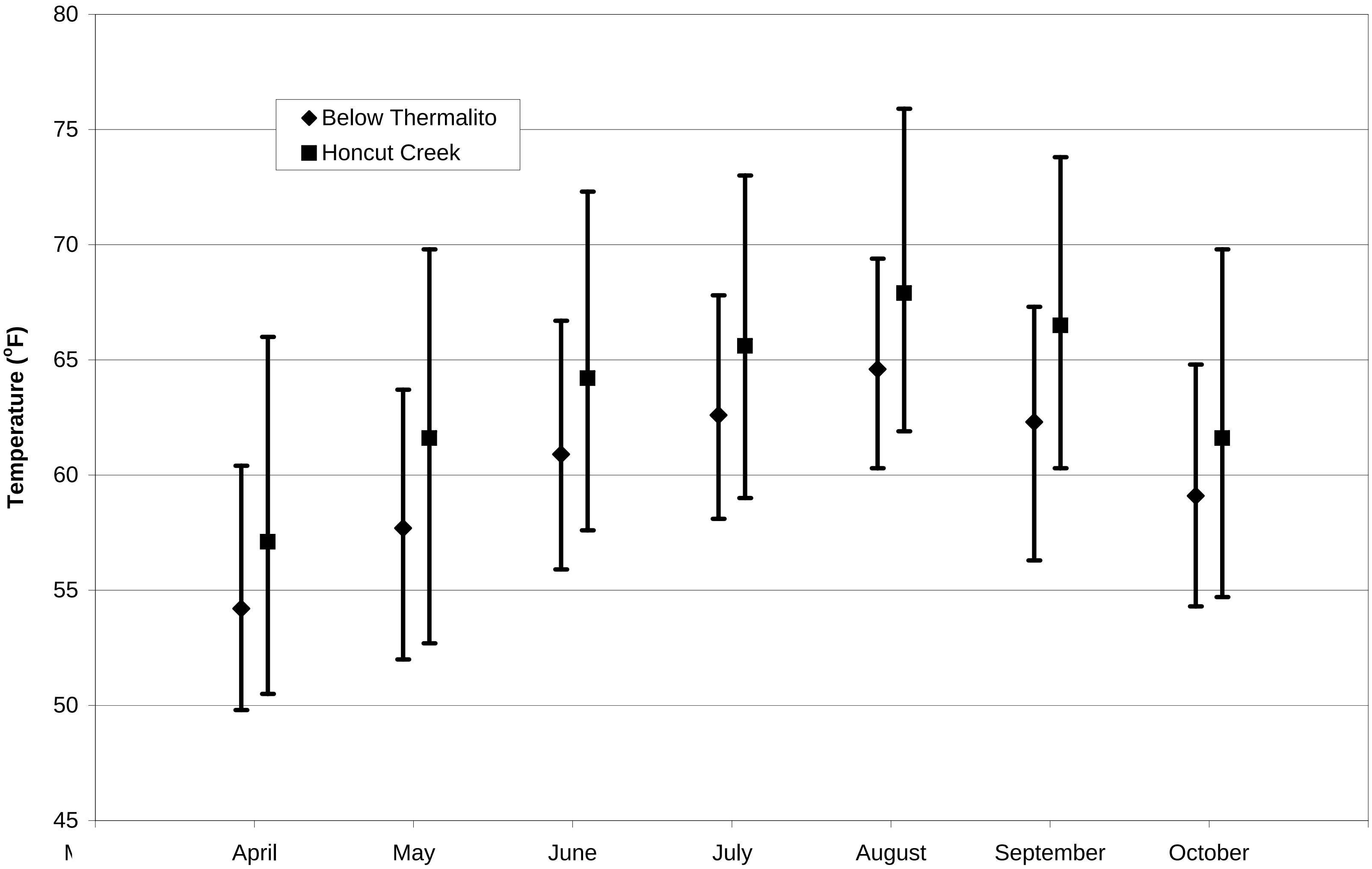


Figure 3. Differences in Daily Average Water Temperatures between Sites Downstream and Upstream of the Afterbay in 2002 and 2003